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Vol. 24 NOVEMBER, 1948 No. 5

# SURGERY

*A Monthly Journal Devoted to the Art and Science of Surgery*

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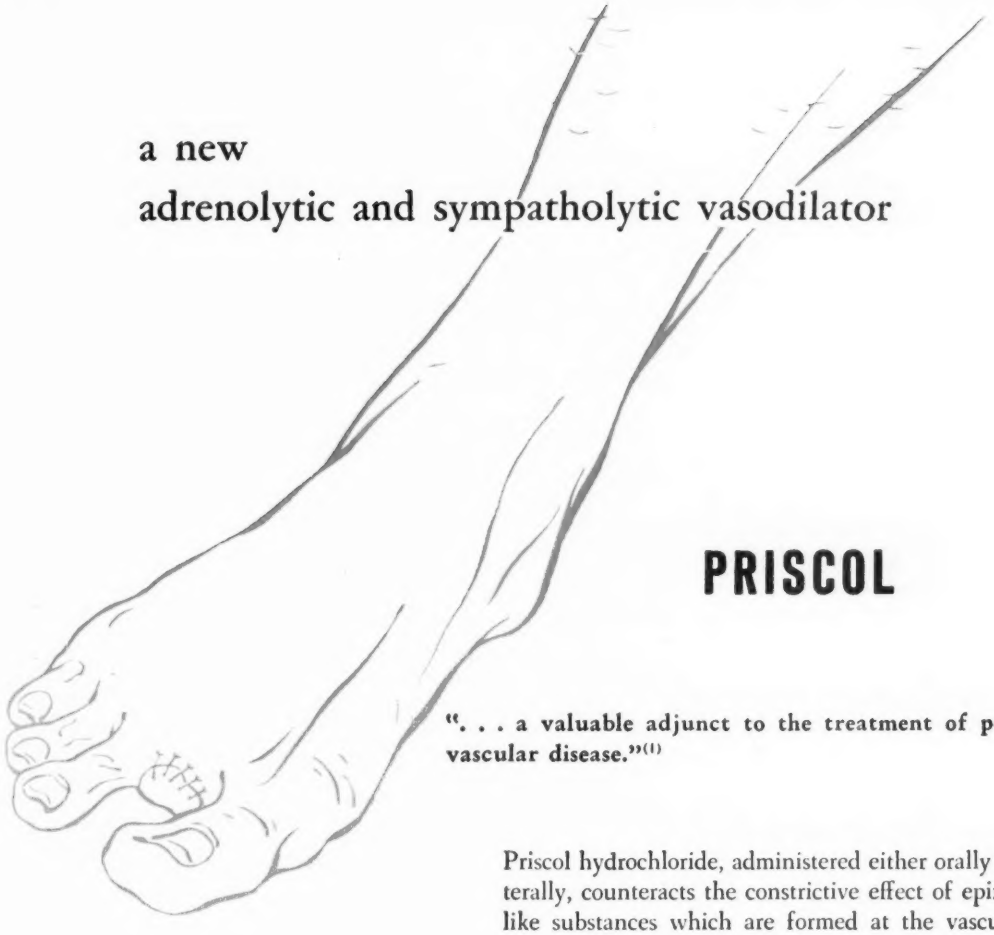

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1. Grimson, K. S., Marzoni, F. A., Reardon, M. J., and Hendrix, J. P.: *Surg.*, 23:728, 1948.

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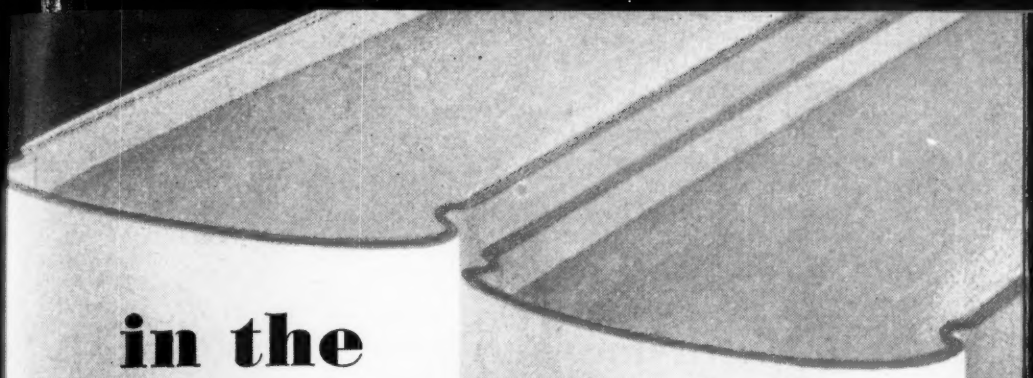

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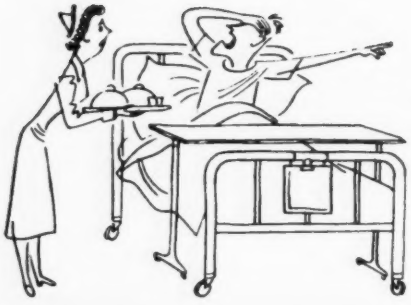

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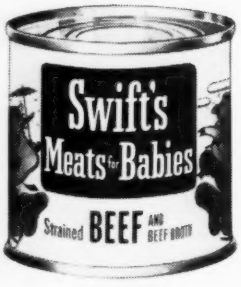


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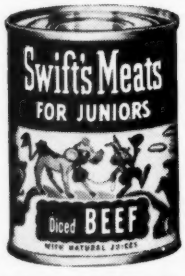

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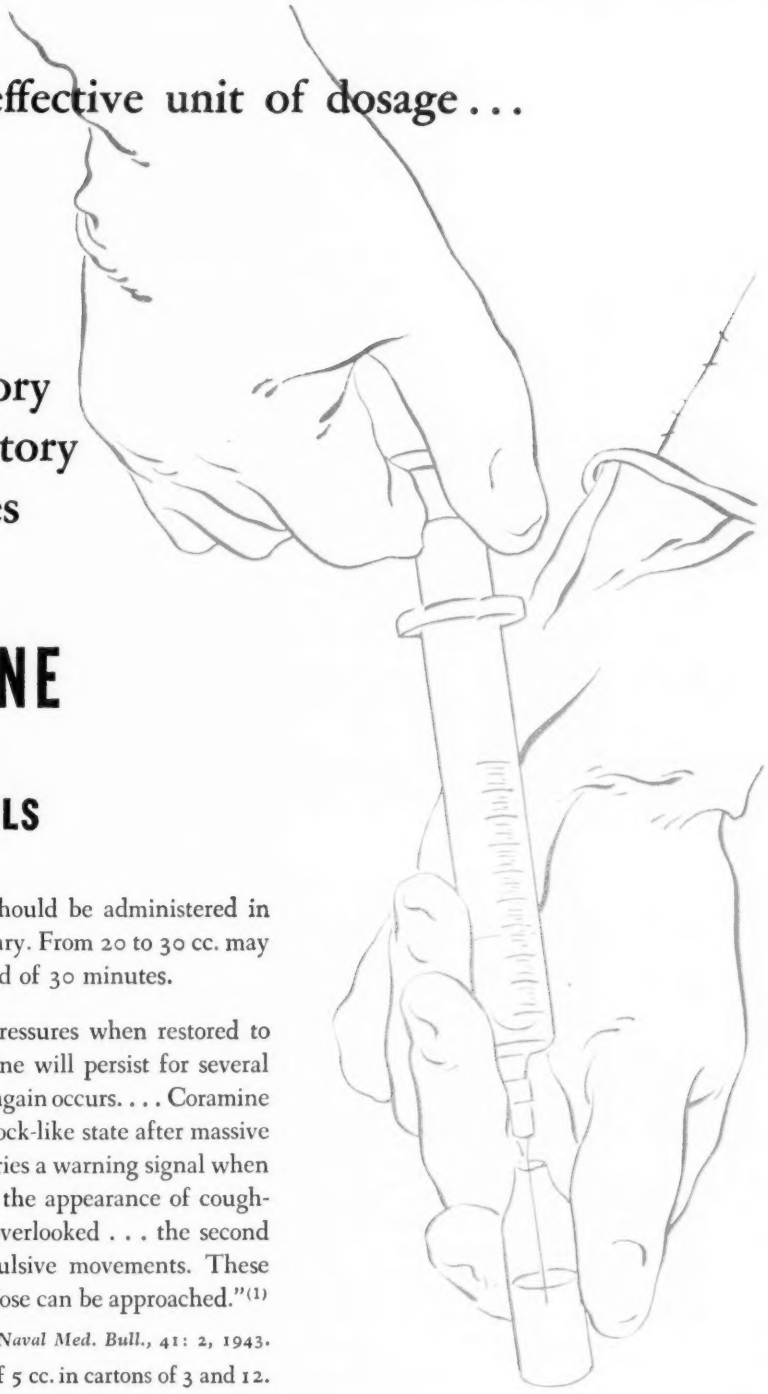

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1. Gunther, L.: *U. S. Naval Med. Bull.*, 41: 2, 1943.

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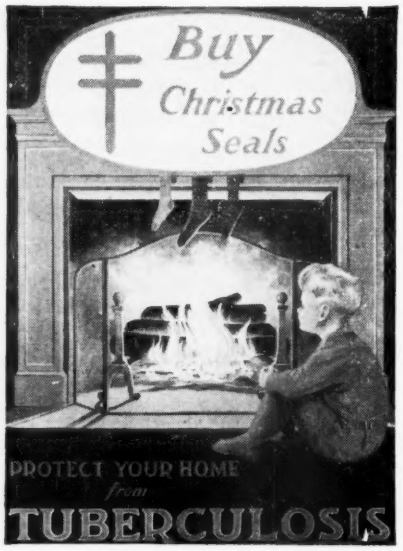

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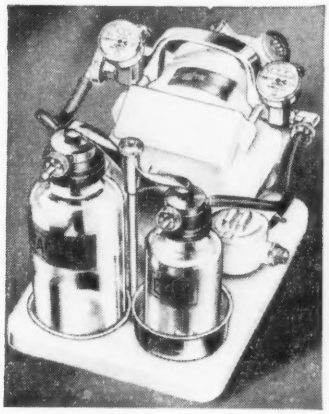

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# SURGERY

VOL. 24 NOVEMBER, 1948 NO. 5

## Original Communications

### CEREBRAL ANGIOGRAPHY IN THE DIAGNOSIS OF INTRACRANIAL HEMATOMAS

KRISTIAN KRISTIANSEN, M.D., MONTREAL, CANADA

*(From Oslo City Hospital, Third Surgical Department)*

HOSPITALS with general surgical services, as well as special neurosurgical clinics, will often have to face the diagnostic and therapeutic difficulties which arise when patients are admitted with acute head injuries. Only a few surgeons get sufficient personal experience in this field of traumatic surgery and there will always be cases that will arouse doubt as to the nature and extent of the intracranial lesion.

Skull fractures are not very significant in this connection. In the treatment of closed head injuries they are of minor importance, in contrast to the importance of fractures in other parts of the human body. In a series of 329 patients with craniocerebral injuries admitted to Oslo City Hospital's Third Surgical Department during the years 1937 to 1939, skull fracture was present in 35 per cent of the cases. The mortality rate was 7.6 per cent of the total number of cases, but the mortality was 18 per cent among the patients with skull fractures. A skull fracture indicates that the patient has sustained an injury of a certain degree of violence. In our experience, a head injury *without* skull fracture will prove fatal only rarely. While this fact may be of a certain prognostic significance, it does not imply that the fracture per se is of any importance as the cause of death.

The site of a skull fracture may give an indication of the side of the hemorrhage but this is not consistent. A lateral dislocation of a calcified pineal shadow is a more reliable guide but it must be remembered that this may also be seen in unilateral cerebral edema.

The chief lesions in patients with craniocerebral injuries are those pertaining to the brain and the meninges. Most of the head injuries in patients admitted to a general surgical department belong to the cerebral concussion group. The treatment in these cases is conservative. Dehydration is used here with magnesium sulfate enemas both as a prevention against cerebral edema and also as a treatment in patients who have already developed edema. Cerebral edema may be the dominant feature of the clinical picture in certain patients,

Received for publication, Jan. 10, 1948.

perhaps particularly in children. This fact is of diagnostic and therapeutic significance because the course of events and the symptoms in cases of cerebral edema are very similar to the symptomatology of intracranial hematomas. The effect of dehydration in these patients is therefore of considerable diagnostic value.

Cerebral contusions and lacerations, except in special cases, do not indicate craniotomy either. The differential diagnosis of contusion, or subdural and extradural hematoma, may offer great difficulties and sometimes the clinical examination fails to provide the correct diagnosis.

Intracranial hematomas, the main subject of this paper, are relatively infrequent lesions in patients with head injuries admitted to a general surgical department. In the series of cases from 1937 to 1939, only 1.2 per cent of the patients presented extradural hematomas and 1.2 per cent subdural.

Probably in no other field of surgery is the operative indication so obvious as in patients with intracranial hematomas. A careful preoperative diagnosis of the nature and the site of the lesion is a prerequisite for an effective treatment. Clinically, the patient's *state of consciousness* is the main guide in determining whether there is to be operative interference or not. Skull fracture, neurological signs, pulse rate, and blood pressure readings are of minor importance in deciding whether a craniotomy is to be performed. A patient whose consciousness is returning should *not* be operated upon, notwithstanding neurological signs, slow pulse, increase of blood pressure, or the presence of a depressed skull fracture as revealed by x-ray examination.

Increasing drowsiness frequently combined with motor restlessness, stupor, and finally coma, which does not recede during dehydration, present a clear operative indication. This decision on the basis of clinical findings presupposes a meticulous vigilance on the part of the nursing staff and the doctors, with observation of changes in the state of consciousness in either direction.

The diagnostic possibilities in such patients are in general four: (1) extradural hematoma, (2) subdural hematoma, (3) intracerebral hematoma, and (4) contusion and laceration with cerebral edema. Combinations of these are frequently met with and add to the difficulties. The significance of cerebral angiography as an aid and supplement to the clinical work can hardly be overestimated, as the examples which are to be presented later will show. In acute head injuries pneumoencephalography is usually refrained from owing to the fact that serious reactions have been observed.

When a patient is admitted with a craniocerebral injury the following questions must be answered:

1. Is the unconsciousness or the impaired consciousness due to an intracranial injury or is there another cause present?
2. What is the nature of the intracranial lesion?
3. Where is the location of the lesion—the focal diagnosis?
4. Is craniotomy indicated?
5. What kind of operation should be performed?

1. It is easy to quote examples of case histories relevant to the first question, but I shall mention only the following case.

A woman, R. H., aged 67 years, was admitted to Oslo City Hospital's Third Surgical Department in March, 1947. She had for the past four months shown symptoms of senile dementia. It was also stated that she had been taking bromides for several weeks before admission. There was obviously a head injury with a fracture in the right temporoparietal region and the clinical signs made a diagnosis of extradural or subdural hematoma quite possible. The content of sodium bromide in the blood, however, was 280 mg. per 100 c.c. The percutaneous arteriography was not quite unequivocal and it was therefore decided to do a craniotomy. A hematoma was not found. There was marked atrophy of the cerebral cortex. A subarachnoid cyst containing about 50 c.c. of clear fluid was emptied. The bromide intoxication was also treated with saline solution and desoxycorticosterone acetate. The recovery was uneventful, but she died several weeks later, in the convalescent department, of pneumonia. The post-mortem examination did not reveal any findings of interest except those already mentioned.

The triad chronic brain disease (senile dementia, arteriosclerosis, cerebral syphilis), acute or chronic intoxications (for example, alcohol), and head injury are frequently met with in different combinations. In this material the significance of alcohol is illustrated, one-third of the patients being more or less intoxicated on admission.

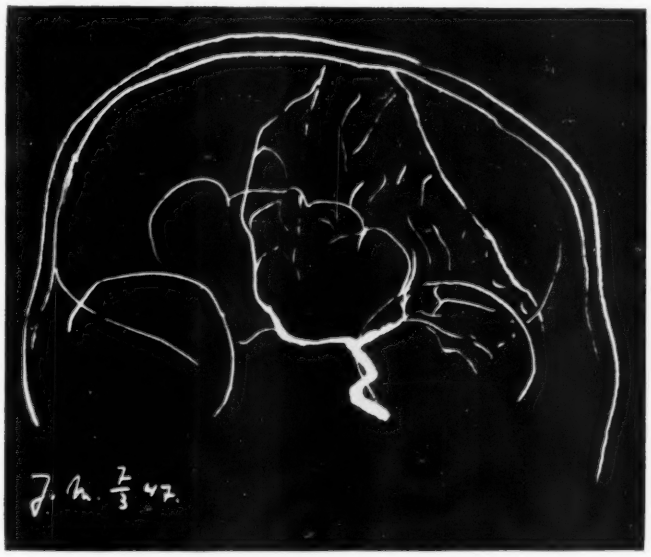

Fig. 1.—J. M. Subdural hematoma. Lack of contrast between skull and surface of brain; dislocation of anterior cerebral artery to the right.

2 and 3. If it is established that the head injury is the cause of the unconsciousness, then the nature of the intracranial lesion must be ascertained. Among the diagnostic aids at our disposal, the percutaneous carotid angiography is found most useful, although the technique may present some difficulties owing to the motor restlessness that often characterizes these patients. Over a period of several years, no serious complications have arisen from using this method in neurological and neurosurgical diseases. The contrast agent is a 35 per cent solution of diodrast. For technical details see Kristiansen (1947), and Engeset and Kristiansen (in press). The focal diagnosis and the question of the exten-

Fig. 2.

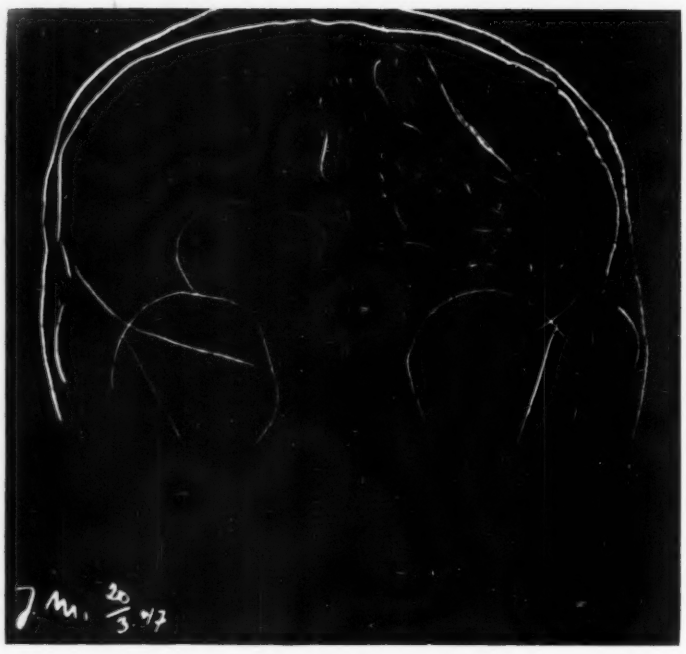


Fig. 3.

Figs. 2 and 3.—J. M. Subdural hematoma. Angiography fourteen days after operation. Arteriogram shows still marked dislocation of anterior cerebral artery. The phlebogram in Fig. 3 (same injection as Fig. 2, exposure 3 seconds later) demonstrates that the cavity has decreased in size.

Fig. 4.—J. M. Phlebogram five weeks after operation, the brain has expanded further.

Fig. 5.—J. M. Phlebogram thirteen weeks postoperatively: the expansion of the brain is complete.

sion of the lesion may also be settled by angiography although certain reservations will have to be kept in mind, as will be illustrated later.

The first case to be reported is that of a patient with an ordinary subdural hematoma.

A man, J. M., aged 54 years, was admitted to one of the medical departments of Oslo City Hospital on March 3, 1947, with a diagnosis of convulsions and drowsiness. He had sustained a head injury in December, 1946, and another head injury a few days before admission to the hospital. With a tentative diagnosis of subdural hematoma he was transferred to the Third Surgical Department. A percutaneous angiography on the left side showed the classical picture of a subdural hematoma with lack of contrast between the brain and the skull, and a dislocation of the anterior cerebral artery to the opposite side (Fig. 1).

The hematoma was evacuated through a small craniotomy and the patient recovered rapidly. During the convalescence, I performed repeated angiographies with a few weeks' interval between each one. The regression of the hematoma cavity and of the displacement of the anterior cerebral artery is demonstrated in Figs. 2, 3, 4, and 5.

The last angiography (Fig. 5) was done in the middle of June, 1947, and shows that the cavity had disappeared and that there remained only a small shift of the anterior cerebral artery to the right.

The next patient represented an unusual combination of a head injury with extradural hematoma, and an intracranial tumor. He died without having been operated upon.

A man, H. T., aged 65 years, was hit by a car on Nov. 11, 1946, and was admitted to the Third Surgical Department immediately afterward with a history of a short period of unconsciousness and retrograde amnesia. He had a fracture in the left occipital region. On admission he was cooperative, but the next day he became drowsy and later comatose. In the meantime, it had been revealed that the patient had been in the hospital in 1942 with a diagnosis of pituitary tumor but had refused operation on account of the fate of his brother. The brother had also had a pituitary tumor and had been operated upon in 1941; he died the day after operation because of a postoperative extradural hematoma.

The sequence of events in the case of this patient favored the diagnosis of traumatic extradural hematoma. The percutaneous arteriography, however, showed the anterior cerebral artery markedly dislocated to the same side, forming the semicircular outline of a pituitary tumor of about the size of a goose egg (Figs. 6 and 7).

Thus, the arteriograms did not confirm the clinical diagnosis of an extradural hematoma. The conclusion was that he probably had hemorrhages of traumatic origin in the tumor which was regarded as inoperable. He died some hours later in increasing coma.

The autopsy revealed a huge pituitary tumor with recent hemorrhages into the tumor tissue. The central parts of the middle cranial fossa were completely destroyed by the tumor growth. Between the base of the skull and the nasal cavity there was direct communication. In addition, the post-mortem examination also revealed an extradural hematoma in the left posterior fossa (Figs. 8 and 9).

It is not possible to decide whether a craniotomy with evacuation of the extradural clot would have saved this patient's life. But the case demonstrates a diagnostic rule that has been of value in other cases also: If a clinical diagnosis of extradural hematoma is made and the carotid angiography proves negative, then a burr hole should be made in the posterior fossa or in a position corresponding to the occipital pole. The extradural hematoma is not as a rule confined to the posterior fossa exclusively, but will also cover a little of the occipital lobe.

Reports on three cases of acute traumatic intracerebral hematoma follow.

Fig. 6.

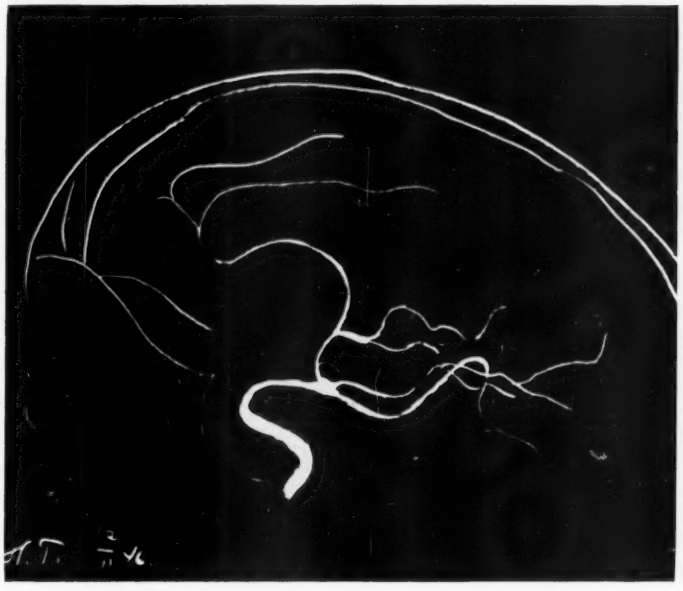

Fig. 7.

Figs. 6 and 7.—H. T. Pituitary tumor, extradural hematoma. Note curved dislocation of anterior cerebral artery both in anteroposterior and lateral views.

Fig. 8.—H. T. Brain sections showing large pituitary tumor with recent hemorrhages.

Fig. 9.—H. T. Extradural clot in left posterior fossa; destruction of central part of middle cranial fossa.

A man, B. A., aged 52 years, was admitted to the Third Surgical Department of Oslo City Hospital on Sept. 7, 1946, after a fall from a high place. He was unconscious, restless, and x-ray examination showed a fracture in the right temporal bone. Due to a technical failure in the x-ray machine an attempt to do an arteriography was unsuccessful.

A subtemporal burr hole was made on the right side corresponding to the site of the fracture, but no extradural or subdural clot was found. As the patient's condition deteriorated after some hours, a left-sided craniotomy was performed. A subdural hematoma of fairly large size was found and evacuated. The operation, however, had no effect; he remained unconscious and died in hyperthermia the next morning.

Post-mortem examination revealed the fracture in the right temporal bone. The subdural hematoma on the left side had been completely removed at the operation and there were no signs of superficial cerebral contusion. After fixation in formalin the brain was cut, and examination of the gross sections revealed a large hematoma in the left temporal lobe (Fig. 10).

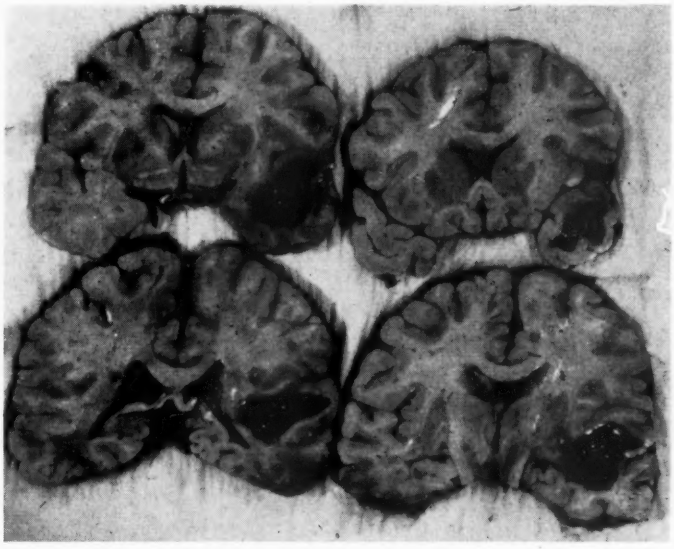

Fig. 10.—B. A. Intracerebral hematoma in left temporal lobe.

The intracerebral damage was undoubtedly the cause of this patient's death. The hyperthermia may be explained as the result of pressure from the hematoma on the central parts of the brain. Without angiography it is hardly possible to diagnose this combination of extracerebral and intracerebral hematoma. This case also demonstrates that a skull fracture is not invariably situated on the same side as the intracranial hematoma.

Traumatic intracerebral hematomas of the kind described here are usually regarded as inoperable. There are, however, frequent reports of successful removals of *chronic* intracerebral hematomas which have been operated upon as a result of faulty diagnoses of intracranial tumors.

I think it is incorrect to regard the acute traumatic intracerebral hematomas of the so-called closed head injuries as unsuitable for operation. If the hematoma is located in a region where it can be reached by a small craniotomy, and

if it can be localized angiographically, I feel that such lesions are very well amenable to operative therapy. The following two cases demonstrate the truth of this point of view.

A man, E. K., aged 56 years, was admitted to a hospital just outside Oslo after being hit by a car Nov. 27, 1946. Due to increasing drowsiness and a left-sided hemiparesis, he was transferred eleven days later to the Third Surgical Department of Oslo City Hospital.

A percutaneous cerebral angiography on the right side showed a very marked dislocation of the anterior cerebral artery to the left, and an exceptional elevation of the Sylvian group (Fig. 11).

A diagnosis of subdural hematoma combined with intracerebral hematoma in the right temporal lobe was made and a small subtemporal craniotomy was performed. A subdural hematoma of about 1 cm. thickness was removed by suction. Medially to that, in the temporal lobe, a large hematoma was found containing mainly clotted blood. The diameter of this intratemporal hematoma was 3 cm. After evacuation of the hematoma and complete hemostasis the wound was closed and the patient recovered rapidly.

Fig. 11.—E. K. Subdural + intracerebral hematoma. Marked dislocation to left of anterior cerebral artery and elevation of Sylvian group which is also displaced medially.

Percutaneous carotid angiography during the postoperative course, with some weeks' interval between each angiography, showed the regression of the abnormal findings (Figs. 12 and 13). Fig. 12 demonstrates also the beautiful bilateral filling of the carotid systems which is obtained when the contralateral common carotid artery is compressed during the injection of contrast. The normally latent anastomosis in the circle of Willis opens instantaneously when the blood flow in one carotid artery is stopped. This bilateral filling is of importance if there is doubt as to the occurrence of a unilateral or a bilateral subdural hematoma.

The other patient, E. J., was a man aged 59 years who was admitted to the Third Surgical Department on Dec. 3, 1946, after a head injury. During the next few days he became drowsy and developed a paresis of the left facial nerve and the left arm. The angiography revealed an archlike elevation of the middle cerebral artery suggesting an expansive process in the right temporal lobe (Figs. 14 and 15).

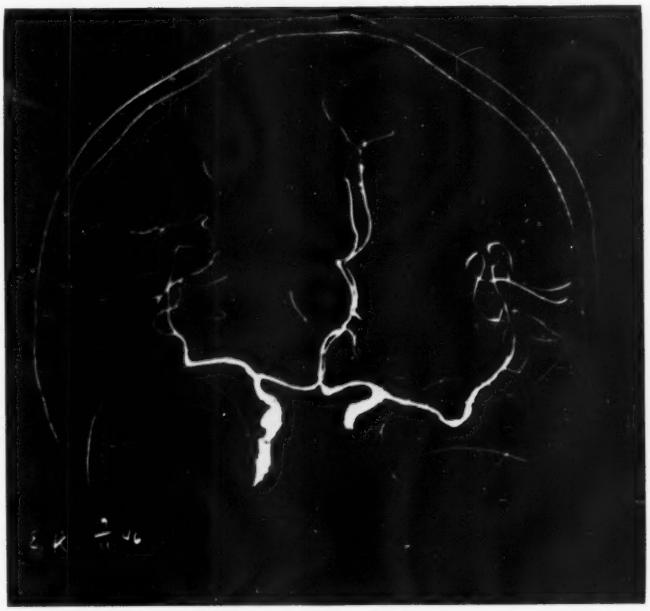

Fig. 12.—E. K. Arteriogram eleven days after operation. Bilateral filling through compression of contralateral carotid artery during contrast injection into right common carotid artery. Dislocations less pronounced.

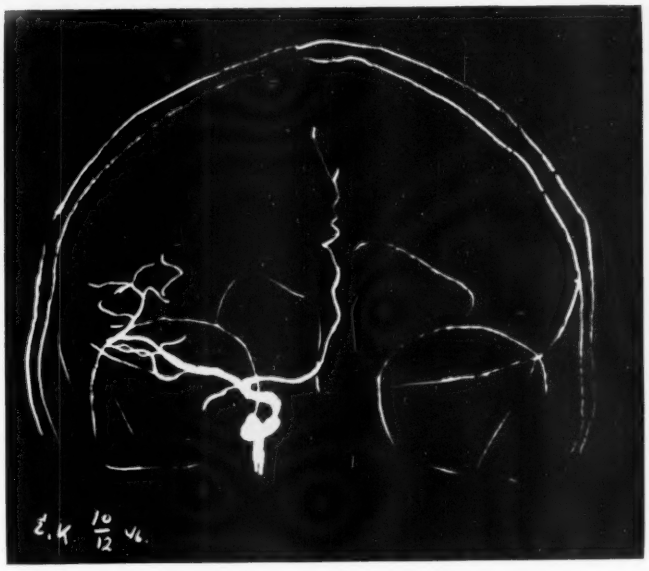


Fig. 13.—E. K. Arteriogram five weeks after operation; only slight displacement of arteries still visible.

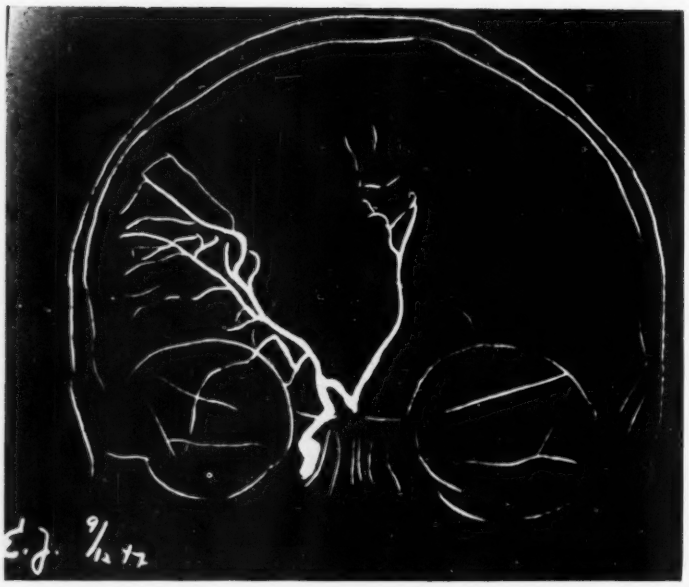

Fig. 14.—E. J. Subdural + intracerebral hematoma. Dislocation of anterior cerebral artery to left; very marked elevation of Sylvian group.

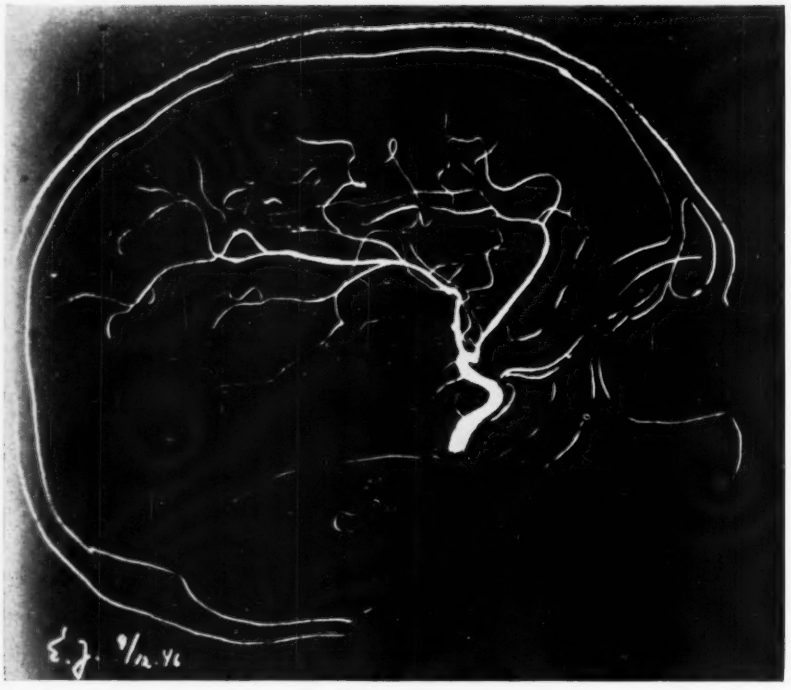

Fig. 15.—E. J. Lateral view arteriogram; archlike elevation of Sylvian group.

A traumatic hematoma in the right temporal lobe was diagnosed, and a small craniotomy performed six days after the injury showed a localized subdural hematoma which was removed. Medially to that there was an intracerebral hematoma in the temporal lobe containing clotted blood and lacerated brain tissue and this hematoma was evacuated. The patient's condition improved rapidly. Another arteriogram on the day of discharge, one month after admission, gave a normal picture of the intracranial vessels (Fig. 16).

Fig. 16.—E. J. Normal arteriogram four weeks after operation.

These last two cases give a demonstration of the value of percutaneous cerebral angiography in acute head injuries, particularly when one is confronted with the case presenting the same kind of lesion which proved fatal. If a preoperative angiography had been successful in that case also, that patient too might have been saved.

All three cases show a combination of a relatively localized subdural hematoma and an intracerebral hematoma in the temporal lobe. The hematomas are probably due to a small cortical contusion with laceration of cortical vessels which give hemorrhage partly outward into the meninges, partly inward into the cerebral substance. The rather protracted course in the two last-mentioned patients may perhaps favor a theory of the hemorrhage occurring at intervals and not immediately following the injury (Bollinger, 1891).

The excellent result of operative treatment on this form of intracerebral hematomas is a temptation to apply a similar therapy in suitable cases of ordinary brain hemorrhages or apoplexies. Such attempts have been made previously by Penfield (1933), among others. I have tried such a procedure in one patient after localization of the hemorrhage by percutaneous angiography. The result was not encouraging in that case due to the fact that the massive hemor-

rhage in the frontal lobe had ruptured into the lateral ventricle. Evacuation of the hematoma had no influence on the patient's condition. Other cases may prove more successful.

4. The fourth question to be answered in cases of head injuries, that is, whether there is indication for operative treatment or not, I have touched on repeatedly in the previous pages. There is a need to stress the point that the patient's state of consciousness and the changes in that state are the main clinical features to be observed.

It has been said that the results of treatment of craniocerebral lesions can never be satisfactory if the surgeon is not "lying with his patients." Everyone who has been engaged in that field of surgery will confirm this view. But as this ideal demand cannot possibly be realized, the value of simple principles of observation both for interns, residents, and nursing staff cannot be overestimated. That simplicity may be attained if every sign indicating clouding of the patient's consciousness is reported at once.

In dubious cases the percutaneous cerebral angiography is completely devoid of danger and affords the necessary diagnostic aid.

5. The last question, that of the operative technique, has also been mentioned previously. The craniotomy in acute head injuries should be performed as a burr hole with nibbling off of the edges until the hole is just sufficiently large to remove the hematoma by suction and to stop bleeding points. Osteoplastic craniotomies should never be performed in acute head injuries as they only add another serious trauma to the original damage. Useless exploratory burr holes in different parts of the skull may be avoided through meticulous neurological examination and preoperative percutaneous cerebral angiography with Diodrast.

SUMMARY

The percutaneous cerebral angiography has proved a valuable diagnostic aid in patients with acute head injuries. Case histories are reported showing the different diagnostic problems occurring in such patients during the first days after the accident. Special attention is given to the combination of subdural and intracerebral hematomas. Without cerebral angiography the presence of the intracerebral clot will easily be overlooked.

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# END RESULTS IN THE TREATMENT OF CANCER OF THE STOMACH

## Analysis of Seven Hundred Ninety-Five Cases

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*(From the Gastric Service of the Memorial Hospital for Cancer and Allied Diseases)*

CANCER of the stomach is the most common and one of the most rapidly fatal of all malignant tumors. As a result, there is not only an understandable pessimism concerning the curability of this disease, but also no hope whatsoever in the minds of the vast majority. Many of our most prominent surgeons, busily engaged in performing operations on the gastrointestinal tract for cancer, have made the statement, both privately and in public, that they have never seen a five-year survivor from gastrectomy for carcinoma of the stomach. If such views are widely entertained by the specialist, the physician in general practice can hardly be expected to search very eagerly for early cancer of the stomach. In the first place, the most logical question might be: Is it possible to recognize gastric cancer in an early curable stage? Can this experience be repeated often enough to warrant continued watchfulness on our part in the hope of discovering the presence of the disease before it has passed beyond all hope of cure?

Before an attempt is made to answer these questions, the symptomatology of gastric cancer might be reviewed. Simple indigestion is probably the most dangerous complaint of any person in middle or late life. Because it is likewise the most common, little attention is paid to the vague but portentous beginnings of what may prove to be a fatal disease. Yet, frequently the warning of something amiss, some aberration from the normal is given in plenty of time if only the patient and the physician were more alert.

Nausea, vomiting, cachexia, emaciation, palpable supraclavicular lymph nodes, and a large epigastric mass spell gastric cancer in capital letters, but so do slight fullness after meals, a recent tendency toward constipation, and a few pounds' loss in weight. More frequently than not, the supposed ulcer syndrome, appearing for the *first time* in a person past 40 years of age, has flashed the signal of a small, relatively slowly growing, ulcerating cancer in a favorable setting. Until proved otherwise, this patient has cancer of the stomach, and if subsequent study reveals the ulcer to be gastric and not duodenal, every effort should be made to remove the lesion as soon as possible.

Many patients are treated for secondary anemia without ascertaining the cause of that anemia. Exertion dyspnea may be the first and only symptom of a slowly bleeding, papillary gastric cancer. Many such patients have received digitalis instead of a gastrointestinal x-ray series.

Probably the earliest symptom of gastric cancer is an awareness that all is not just right, though often the patient cannot say where or why. For the

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first time in his life, he may become conscious of a protracted change in his sense of well-being; he may be aware of his stomach (stomach consciousness) where before he did not know it existed. He may not have cancer of the stomach, but only an adequately conducted gastrointestinal x-ray series and fluoroscopy after barium swallowing, supervised by a competent radiologist, will settle the question. A patient is seldom annoyed when told he does not have a serious gastric disorder.

Once a diagnosis of cancer of the stomach is established, is any useful purpose served by subjecting the patient to laparotomy with the hope of performing either partial or complete gastrectomy? It is our considered opinion that the hope for cure is a very definite one which should be offered all such patients, in greater numbers as each year goes by. In order that we may appreciate the change in our concepts concerning the outlook in cancer of the stomach, let us examine the material at a large clinic in New York City, studied over a period of thirty years.

## MATERIAL FOR STUDY

From 1916 through 1941, 795 patients suffering from gastric cancer were examined and treated at the Memorial Hospital for Cancer and Allied Diseases. Of that entire number only 26, or 3.4 per cent, survived for a five-year period without recurrence after subtotal gastrectomy. This curability rate of 3.4 per cent is not a fair evaluation of the prospect today because it includes the early history of the hospital as far back as 1916, and is based on a resectability rate which is only slightly higher, namely, 10 per cent (Table I). Five of the patients operated on prior to 1936 were living and well for more than ten years. At first glance, this bare statement of fact appears gloomy indeed, almost forcing us to conclude that we have been wasting our time and many thousands of dollars in attempting to cure patients of a disease which is almost invariably fatal. Yet, life has been precious to those twenty-six people who have no great interest in statistics or what happened to all the others. Upon closer scrutiny of the material, we readily observe a very remarkable change in the method of management of cancer of the stomach. Palliative operations were common and resections were rarely performed in the earlier decade; now the reverse is true. This change has been accompanied by a remarkable upward trend in the cure curve of end results.

TABLE I. FIVE-YEAR SURVIVAL FOLLOWING RESECTION FOR GASTRIC CANCER, FROM 1916 THROUGH 1941

| TYPE OF CASE | TOTAL CASES | FIVE-YEAR SURVIVAL | |
|---|---|---|---|
| | | NUMBER | PER CENT |
| Total patients with gastric cancer | 795 | 26 | 3.4 |
| Number surviving gastrectomy | 75 | 26 | 34.7 |

## THE RESECTABILITY OF GASTRIC CANCER

From 1916 until 1930, of 272 patients who were seen in our clinic, only 8, or 2.9 per cent, had resectable gastric cancers. As it later became evident that there was obvious need for segregating such patients in a special clinic

devoted to tumors of the stomach, the resectability rate increased to 7.7 per cent during the years of 1931 through 1936, and 26.2 per cent for the years of 1937 through 1941. In a far shorter period, more patients were seen, and what is more important, a greater number of resections was performed. Whereas only one of the few patients undergoing gastrectomy before 1931 survived for a five-year period, an increasingly large number was now being offered the chance of cure. Within the last eight years, techniques of two operative procedures became more widely employed and were standardized in clinics throughout the world. We refer to (a) the procedure known as "total" or "complete" gastrectomy and (b) transthoracic resection of the gastric cardia. Greater understanding of preoperative and postoperative care and advances in anesthesiology made these operations less hazardous and part of the armamentarium of

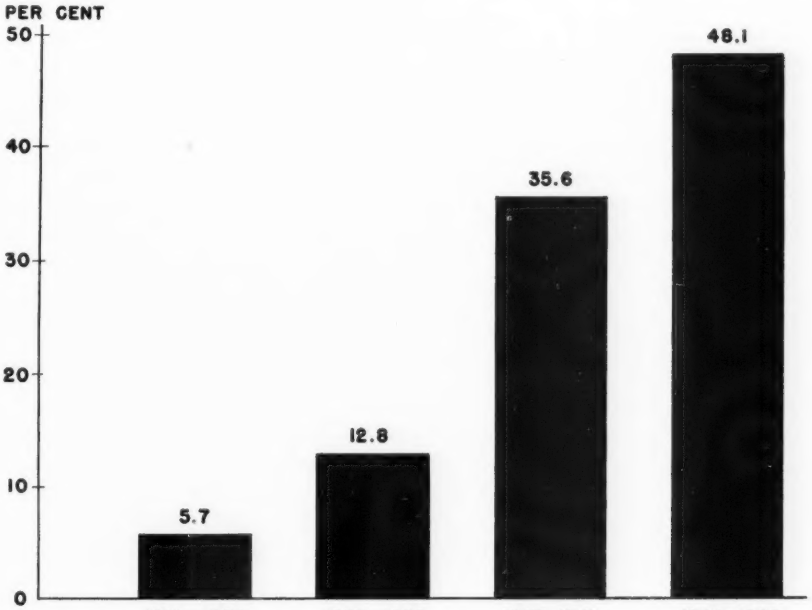


Fig. 1.—The resectability of gastric cancer, The Gastric Service of the Memorial Hospital, New York, N. Y., from 1916 through 1946.

many gastric surgeons. As a result, no longer was any cancer of the stomach not resectable as long as the disease was confined to that organ and adjacent lymph nodes and not fixed to structures whose removal might not be compatible with life. Hence, we see that in the years 1942 through 1946, not only were there many more patients treated than in the previous five-year period, but also the resectability rate soared to 39.8 per cent. In fact, 48.1 per cent of all patients submitted to laparotomy underwent either subtotal or total gastrectomy and 82 per cent were operated on for palliative or curative purposes (Table II). Thus a far greater number of patients was given a chance to live.

TABLE II. OPERABILITY AND RESECTABILITY OF GASTRIC CANCER, FROM 1931 THROUGH 1946

| PERIOD | TOTAL CASES | OPERABILITY | | RESECTABILITY | | |
|---|---|---|---|---|---|---|
| | | NUMBER | PER CENT OF TOTAL CASES | NUMBER | PER CENT OF OPERABLE CASES | PER CENT OF TOTAL CASES |
| 1916 to 1930 | 272 | 141 | 51.8 | 8 | 5.7 | 2.9 |
| 1931 to 1936 | 245 | 149 | 60.8 | 19 | 12.8 | 7.7 |
| 1937 to 1941 | 278 | 205 | 73.7 | 73 | 35.6 | 26.2 |
| 1942 to 1946 | 405 | 335 | 82.7 | 161 | 48.1 | 39.8 |

Significantly, 34.7 per cent of the 75 survivors of resection lived for five years without evidence of recurrence. It is too early as yet to evaluate the end results of treatment in the years 1942 through 1946, but it seems logical to believe that a far greater number of patients will have been offered a chance to survive for many years as a direct result of the increase in the resectability rate and lowered operative mortality.

### THE OPERATIVE MORTALITY FOR CANCER OF THE STOMACH

Does the increase in the resectability rate for gastric cancer carry with it an unjustified hazard? Here we encounter what, at first glance, may be considered as conflicting results. In the early period from 1916 through 1930, five of eight patients undergoing gastric resection did not survive the operation. The operative mortality declined from 62.5 per cent to 31.6 per cent during the next five years. Yet, the truly gratifying improvement by 1941 of 19.2 per cent did not appear to continue during the last five-year period (21.7 per cent). This seeming paradox in spite of the newer advances in pre- and postoperative care and anesthesiology is explained by various factors. Having extended the scope of subtotal gastrectomy to its fullest degree, surgeons realized more fully that every attempt must be made to remove a cancerous stomach wherever possible. The techniques of total gastrectomy and transthoracic resection of the gastric cardia were, therefore, applied with ever-increasing frequency. Obviously, a greater operative hazard had to be faced, as both these procedures carry a high operative mortality, and this figure is included with the over-all mortality rate for gastric resections of all types. Furthermore, during the last five years at the Memorial Hospital 42.8 per cent of all gastric resections for cancer were of this major character, namely, total gastrectomy and transthoracic cardiectomy (Table III). Of ninety-two subtotal gastrectomies for cancer (1942 through 1946), there were only nine operative deaths, or 9.8 per cent. It must never be forgotten, however, that if any gastric cancer is not resected, the patient invariably dies. Here again, it is too early to evaluate the end results obtained by such massive operations as total gastrectomy and transthoracic cardiectomy, but over eighty persons have been given an opportunity for life which could not possibly have been otherwise afforded.

### FACTORS WHICH INFLUENCE THE END RESULTS IN THE TREATMENT OF GASTRIC CANCER

*Duration of Symptoms in Relation to Five-Year Survival Following Resection for Gastric Cancer.*—The application of this factor does not pass the

TABLE III. OPERATIVE MORTALITY FROM ALL OPERATIONS FOR GASTRIC CANCER, FROM 1916 THROUGH 1946

| TYPE OF OPERATION | TOTAL CASES | OPERATIVE DEATHS | | TOTAL CASES | OPERATIVE DEATHS | |
|---|---|---|---|---|---|---|
| | | NUMBER | PER CENT | | NUMBER | PER CENT |
| | *1916 through 1930* | | | *1931 through 1936* | | |
| All operations | 104 | 34 | 32.7 | 123 | 17 | 13.8 |
| Exploratory operation | 24 | 2 | 8.3 | 43 | 5 | 11.6 |
| Palliative operation | 72 | 27 | 37.5 | 61 | 6 | 9.8 |
| Resection | 8 | 5 | 62.5 | 19 | 6 | 31.6 |
| Subtotal resection | 8 | 5 | 62.5 | 18 | 6 | 33.3 |
| Resection of the cardia | | | | 1 | 0 | 0.0 |
| Total gastrectomy | | | | | | |
| | *1937 through 1941* | | | *1942 through 1946* | | |
| All operations | 197 | 31 | 15.7 | 335 | 57 | 17.0 |
| Exploratory operation | 57 | 6 | 10.5 | 100 | 5 | 5.0 |
| Palliative operation | 67 | 11 | 16.4 | 74 | 17 | 23.0 |
| Resection | 73 | 14 | 19.2 | 161 | 35 | 21.7 |
| Subtotal resection | 58 | 9 | 15.5 | 92 | 9 | 9.8 |
| Resection of the cardia | 5 | 2 | 40.0 | 36 | 14 | 38.9 |
| Total gastrectomy | 10 | 3 | 30.0 | 33 | 12 | 36.4 |

test of critical statistical analysis, the reason being that the minimum and maximum duration are too widely separated. The average duration of preoperative symptoms for 9.7 months obtains fairly evenly both for the patients who survived five years without recurrence and for those who died of recurrent cancer in a shorter period (Table IV). We had previously entertained the clinical impression that the patients whose preoperative duration of symptoms was short, very frequently presented inoperable cancers at laparotomy, and conversely, we had observed that some patients with a long history still had cancers readily removable. Two of these patients in the five-year-cure group were more than 70 years of age at the time of gastric resection.

TABLE IV. DURATION OF SYMPTOMS IN RELATION TO FIVE-YEAR SURVIVAL FOLLOWING RESECTION FOR GASTRIC CANCER, FROM 1931 THROUGH 1941

| SURVIVAL PERIOD | NUMBER | AVERAGE DURATION OF SYMPTOMS (MO.) |
|---|---|---|
| Total | 66 | 9.7 |
| Patients surviving less than five years | 46 | 9.9 |
| Patients surviving five years or more | 20 | 9.3 |

*Does the Gross Pathologic Type of Tumor Have Any Bearing on Ultimate Prognosis?* We had anticipated a higher percentage of long-term survivors in patients with gastric cancer of the polypoid exophytic type. Of nineteen patients with such tumors, only five lived without recurrence for more than five years subsequent to gastrectomy (26.3 per cent). On the other hand, one-third of our patients with ulcerating gastric cancers, who survived resection, attained definitive cures (33.9 per cent). The prognosis for annular cancers, contrary to our preconceived notion, is less optimistic as we find now that these cancers have usually metastasized by the time surgical intervention is done (22.7 per cent.) One-quarter of all infiltrating gastric cancers, removed surgically, are apparently completely controlled, as judged by the survival ratios of these patients (25 per cent). Carcinoma in situ, the miniature focal can-

cer of the stomach is, of course, the most favorable, or rather the least dangerous of all gastric cancers. A patient surviving partial gastrectomy for this tumor may expect a cure, provided he doesn't succumb to another disease in the meantime (100 per cent) (Table V). An exception to this last statement may result in the instance of a patient recently treated—a 70-year-old woman who successfully underwent subtotal gastrectomy for a small antral cancer. In the specimen were found at least a dozen minute, sessile mucosal plaques, each of which on microscopic study proved to be carcinoma in situ. No one knows the time it would take for any one of these tiny focal cancers to grow sufficiently to cause the symptoms and signs of gross gastric cancer. Because of the multi-

TABLE V. GROSS PATHOLOGY IN RELATION TO OPERATIVE SURVIVAL FOLLOWING RESECTION FOR GASTRIC CANCER, FROM 1916 THROUGH 1941

| GROSS PATHOLOGY | ALL OPERATIVE SURVIVALS | SURVIVAL UNDER FIVE YEARS | SURVIVAL OF FIVE YEARS OR MORE | | | | |
|---|---|---|---|---|---|---|---|
| | | | TOTAL | 5-7 YR. | 7-9 YR. | 10-15 YR. | 15 YR. |
| Total cases | 75 | 49 | 26 | 14 | 7 | 4 | 1 |
| Ulcerating | 62 | 41 | 21 | 12 | 6 | 3 | |
| Annular | 22 | 17 | 5 | 2 | 1 | 1 | 1 |
| Polypoid | 19 | 14 | 5 | 1 | 3 | 1 | |
| Infiltrating | 16 | 12 | 4 | | 3 | 1 | |
| In situ | 2 | | 2 | 2 | | | |

centric origin, we naturally assume that other similar foci may be present in the residual proximal stomach. We must, therefore, decide whether to perform a total gastrectomy in this 70-year-old woman with the attendant risk of this operation or to watch her constantly by fluoroscopic and gastroscopic surveillance during the remainder of her life.

*Presence or Absence of Metastases in Regional Lymph Nodes.*—The absence of metastatic cancer in the lymph nodes removed with the resected stomach has always been heralded as an important factor of good prognosis in the evaluation of end results, but the total number of patients surviving without recurrence for five years after resection is so small that percentage figures offer information of only relative value. Of our patients who reached the period of definitive cure, 69.2 per cent did not have metastases in the perigastric lymph nodes. The surprising fact is that in the remainder of our long-term survivors, that is, 30.8 per cent of the cured cases, cancer was demonstrably present in the excised lymph nodes (Table VI). It is a truism that cancer of the stomach is not incurable when it has passed beyond the confines of the stomach to the perigastric lymph nodes, yet this fact is often not appreciated by surgeons who refuse to perform gastrectomy because of apparently gross metastatic cancer in lymph nodes adjacent to the primary tumor. In the first place, even expert pathologists frequently are in error concerning the gross appearance of cancer in lymph nodes, and in the second place, such lesions if widely resected may be permanently eradicated.

The relative prognosis of patients who have undergone gastrectomy for cancer with and without metastasis to regional lymph nodes may also be expressed in the following manner: (a) those without metastases to lymph nodes—42.8 per cent five-year survival, (b) those with proved metastases to lymph nodes—24.2 per cent five-year survival.

TABLE VI. MICROSCOPIC PATHOLOGY OF GASTRIC CANCER IN RELATION TO OPERATIVE SURVIVAL (METASTASIS TO REGIONAL LYMPH NODES) FROM 1916 THROUGH 1941

| MICROSCOPIC PATHOLOGY | SURVIVAL OF LESS THAN FIVE YEARS | | | SURVIVAL OF FIVE YEARS OR MORE | | |
|---|---|---|---|---|---|---|
| | TOTAL CASES | WITH NODAL METASTASES | WITHOUT NODAL METASTASES | TOTAL CASES | WITH NODAL METASTASES | WITHOUT NODAL METASTASES |
| Total | 49 | 25 | 24 | 26 | 8 | 18 |
| Ungraded | 4 | 3 | 1 | | | |
| Superficial adenocarcinoma | | | | 2 | | 2 |
| Adenocarcinoma | 29 | 17 | 12 | 15 | 2 | 13 |
| Adenocarcinoma with gelatinous features | 7 | 1 | 6 | 1 | | 1 |
| Adenocarcinoma with serosal penetration | 8 | 4 | 4 | 7 | 5 | 2 |
| Adenocarcinoma with gelatinous features and serosal penetration | | | | 1 | | 1 |
| Linitis plastica | 1 | 1 | | | | |

*The Microscopic Grade of Gastric Cancer.*—The prognosis of gastric cancer can definitely be evaluated by grouping the histologic grading of the resected tumors. If we group the total cases as charted in Table VII, it will be seen that the percentage of five-year survivals after resection becomes progressively lower with the ascending degrees of malignancy. For example:

| GRADE | DEFINITIVE CURES FIVE YEARS (PER CENT) | SURVIVAL OF LESS THAN FIVE YEARS (PER CENT) |
|---|---|---|
| Grade I | 100.0 | 0.0 |
| Grade II | 41.7 | 58.3 |
| Grade III | 30.0 | 70.0 |
| Grade IV | 16.7 | 83.3 |

From these facts we may deductively reason that patients with the relatively rare Grade I cancer of the stomach (operable) have an extraordinarily

TABLE VII. MICROSCOPIC PATHOLOGY OF GASTRIC CANCER IN RELATION TO OPERATIVE SURVIVAL (HISTOLOGIC GRADE OF TUMOR) FROM 1916 THROUGH 1946

| MICROSCOPIC PATHOLOGY | SURVIVAL OF LESS THAN FIVE YEARS | | | | | SURVIVAL OF FIVE YEARS OR MORE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL CASES | I | II | III | IV | TOTAL CASES | I | II | III | IV |
| Total | 49* | | 14 | 21 | 10 | 26 | 5 | 10 | 9 | 2 |
| Superficial adenocarcinoma | | | | | | 2 | 2 | | | |
| Adenocarcinoma | 29 | | 9 | 13 | 7 | 15 | 1 | 7 | 5 | 2 |
| Adenocarcinoma with gelatinous features | 7 | | 1 | 6 | | 1 | 1 | | | |
| Adenocarcinoma with serosal penetration | 8 | | 4 | 1 | 3 | 7 | | 3 | 4 | |
| Adenocarcinoma with gelatinous features and serosal penetration | | | | | | 1 | 1 | | | |
| Linitis plastica | 1 | | | 1 | | | | | | |

*The total includes four ungraded carcinomas.

TABLE VIII. FIVE-YEAR SURVIVAL FOLLOWING RESECTIONS FOR GASTRIC CANCER IN RELATION TO THE HISTOLOGIC GRADE OF TUMOR AND METASTASES TO REGIONAL LYMPH NODES FROM 1916 THROUGH 1941

| LENGTH OF SURVIVAL | FIVE-YEAR SURVIVALS | HISTOLOGIC GRADE OF TUMOR | | | | METASTASIS TO REGIONAL LYMPH NODES | |
|---|---|---|---|---|---|---|---|
| | | GRADE I | GRADE II | GRADE III | GRADE IV | WITH | WITHOUT |
| Total | 26 | 5 | 10 | 9 | 2 | 8 | 18 |
| 5 to 7 yr. | 14* | 3 | 5 | 4 | 2 | 3 | 11 |
| 7 to 10 yr. | 7 | 2 | 2 | 3 | | 3 | 4 |
| 10 to 15 yr. | 4† | | 3 | 1 | | 2 | 2 |
| 15 yrs. | 1 | | | 1 | | | 1 |

*Two patients have died—one of recurrent disease and one of heart disease.
†One patient died of heart disease 10 years postoperatively.

good chance for permanent cure and, furthermore, that patients with the anaplastic Grade IV gastric cancers are not absolutely hopeless (Table VII).

*The Prognostic Significance of Gelatinous Features in Gastric Cancer.*—Billroth's first successful gastrectomy on the historic patient, Theresa Heller, was for a gelatinous cancer, but the patient died four and one-half months later, the post-mortem report emphasizing "a gelatinous metamorphosis of the peritoneum." One would ordinarily think of such gelatinous features as a degenerative phenomenon and tend to attribute no significance to this occurrence, but experience has shown that few patients with this type of gastric cancer are cured. The mucinous material containing groups of cancer cells early permeates the subserosal lymphatics, and diffuse peritoneal carcinosis with ascites is usually the result. In our group of nine patients who had gastrectomy for such gelatinous or mucocarcinomas, only two lived without recurrence for five years (22 per cent) although seven of these nine resected specimens revealed no evidence of metastases in perigastric lymph nodes (Table VII).

*The Prognostic Significance of Serosal Penetration by Gastric Cancer.*—We have been told that serosal penetration by gastric cancer either resulting in perforation into the abdominal cavity or fixation to an adjacent organ, such as the pancreas, liver, spleen, or transverse colon, constitutes a menace as far as the prospect of cure is concerned. However, it has been our experience after spending tedious hours removing such gastric cancers, even with parts of neighboring viscera, that many of these patients surprised us by living for many years. Of sixteen patients who had this complication and whose gastric cancers were still operable, eight are living and well five years later (50 per cent) and one of these patients may be classified as a sixteen-year cure. In six of these eight long-term survivors of gastrectomy, metastatic cancer was present in lymph nodes removed with the gastric tumor. Let us urge the surgeon, therefore, to attempt the removal of these gastric cancers which invade or are adherent to liver, pancreas, spleen, and transverse colon, as it is our belief and contention that a high incidence of five-year cures may be obtained, even if metastases occur in the perigastric lymph nodes.

## CONCLUSIONS

Until the fundamental nature of gastric cancer is understood, it is difficult to escape the following conclusions:

1. *Pay strict attention* to the digestive complaints of all patients over 40 years of age so as to establish early diagnosis.

2. *Increase the resectability rate* so that an even higher proportion of gastric tumors is resected.

3. *Resect all gastric cancers* technically removable even if (a) the tumor is attached to an adjacent organ (spleen, colon, liver, pancreas); (b) apparent metastatic cancer is seen and felt in perigastric lymph nodes; (c) the entire stomach must be sacrificed; or (d) the cancer involves the abdominal esophagus.

4. *Decrease the postoperative mortality* by improvement in operative technique and close pre- and postoperative supervision, so that more patients survive the operation and may hope for a curative end result.

## SUMMARY

1. In the first quarter century of effort at the Memorial Hospital for Cancer and Allied Diseases, the curability of gastric cancer was only 3 to 4 per cent of all patients with this disease. However, the resectability rate in these early years was only 10 per cent, which would indicate that about one-third of all patients undergoing gastrectomy were cured.

2. The resectability rate for gastric cancer has shown progressive improvement for each succeeding period, for example, the percentage resected among all patients with gastric cancer has been: 1916 to 1930, 2.9 per cent; 1931 to 1936, 7.7 per cent; 1937 to 1941, 26.2 per cent; 1942 to 1946, 39.8 per cent. Of all patients subjected to laparotomy between 1942 and 1946, 48.1 per cent had successful gastrectomy for cancer and 82 per cent of all patients with gastric cancer underwent some type of operative procedure designed for cure or palliation.

3. Of seventy-five patients surviving gastrectomy for cancer, twenty-six, or 34.7 per cent, lived five years without recurrence.

4. The operative mortality for subtotal gastrectomy has decreased with each succeeding surgical period for example, 1916 to 1930, 62.5 per cent; 1931 to 1936, 33.3 per cent; 1937 to 1941, 15.5 per cent; 1942 to 1946, 9.8 per cent.

5. More than eighty patients in the last quinquennial period have had either total gastrectomy or transthoracic cardiectomy for gastric cancer (Memorial Hospital series).

6. The preoperative duration of symptoms apparently has no influence on the curability of those patients who have had gastrectomy for cancer.

7. The gross pathologic type of cancer does have a bearing on the prognosis following gastric resection, for example, the percentage of five-year cures among the following types: carcinoma in situ, 100 per cent; ulcerocancer, 33.9 per cent; polypoid cancer, 26.3 per cent; infiltrating cancer, 25 per cent; annular cancer, 22.7 per cent.

8. The presence of metastatic cancer in the perigastric lymph nodes of resected gastric cancers does influence the end results of treatment, for example, those patients without nodal metastases had 42.8 per cent five-year survival without recurrence and those patients with proved metastases to nodes had 24.2 per cent definitive five-year cures.

9. The histologic grade of the resected gastric cancer has a most decided bearing on the number of five-year definitive cures, for example, Grade I, 100 per cent; Grade II, 41.7 per cent; Grade III, 30 per cent; Grade IV, 16.7 per cent.

10. The so-called gelatinous or mucocarcinoma of the stomach is nearly always attended by a bad prognosis. Only 22 per cent of this small group of patients achieved the five-year period of definitive cure, although seven of these nine patients did not have metastatic involvement of perigastric lymph nodes.

11. Local serosal penetration resulting in fixation to adjacent organs whose removal is compatible with life may be a favorable rather than an unfavorable complication, perhaps because of the more radical operation that must necessarily be done. In our own series of sixteen patients who had these radical operations, eight were living and well five years later, a curability of 50 per cent.

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# POSTCHOLECYSTECTOMY SYMPTOMS DUE TO CYSTIC DUCT REMNANT

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SYMPTOMS referable to the biliary tract following extirpation of the gall bladder have been designated by such names as postcholecystectomy syndrome, biliary dyskinesia, and biliary dyssynergia. In some cases a definite organic cause for the symptons has been discovered, while in others no demonstrable cause has been found. Among the more tangible causes are stone in the extrahepatic ducts, stricture or angulation of the extrahepatic ducts, cholangitis, hepatitis, pancreatitis, errors in diagnosis, ill-advised operation, neurogenic factors, and others.[1, 3, 5-9] The problems of diagnosis and differential diagnosis may be extremely difficult. Although a remnant of the cystic duct left at the time of cholecystectomy has been recognized as a cause of biliary tract symptoms, it has received relatively scant attention.

Seven personal cases in which operation revealed a cystic duct remnant to be apparently the sole cause of postcholecystectomy symptoms and in which removal of the remnant relieved the symptoms completely prompted this communication. In additon to the seven cases referred to, two more instances of cystic duct remnant have been encountered but because one was complicated by a stone in the common bile duct and the other by a stricture of the common bile duct, the latter presumably secondary to the cystic duct remnant, they will not be included in the series. Both patients, however, had excellent results following operation.

Of the seven patients of this report two were men, five women (Table I). Their ages varied between 28 and 73 years. In all instances the cholecystectomy had been performed elsewhere and as far as could be determined from their histories the diagnosis of gall bladder disease and the indications for surgical treatment had been adequate. The gall bladder in these patients had been removed from nine months to eighteen years before they had sought surgical relief from postcholecystectomy symptoms. In all cases there had been both pain and jaundice, both of which in some instances had been marked in degree. Symptoms had appeared first after cholecystectomy from "at once" to fifteen years.

The diagnosis in each case prior to operation for postcholecystectomy symptoms was a suspected stone in the common duct though in the last three, because of experience in the previous cases, a cystic duct remnant had been recorded as an additional possibility. The operative procedure in each case, in addition to general exploration and particular inspection of the liver, duodenum, and pancreas, was directed at accurate exposure of the extrahepatic ducts and careful exploration of them by probing and irrigation. In each case the cystic duct

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TABLE I

| CASE NO. | PATIENT | SEX | AGE (YR.) | DATE OF CHOLECYSTECTOMY ELSEWHERE | INTERVAL BEFORE SYMPTOMS RECURRED | DATE OF REMOVAL OF CYSTIC DUCT REMNANT | LENGTH OF CYSTIC DUCT REMNANT (CM.) | FOLLOW-UP RESULT (1947) | FOLLOW-UP INTERVAL (YR.) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A. T. L. (124711) | M | 68 | 1922 | 15 yr. | July 24, 1939 | 2-3 | Excellent | 7+ |
| 2 | L. T. (171708) | F | 39 | 1932 | 8 yr. | Sept. 3, 1941 | 3-4 | Excellent | 5+ |
| 3 | H. L. B. (196812) | F | 73 | 1939 | 5 yr. | July 19, 1944 | 2-3 | Excellent | 2+ |
| 4 | J. H. C. (211452) | F | 28 | 1943 | 6 wk. | March 21, 1945 | 2.5 | Excellent | 2+ |
| 5 | M. G. W. (219620) | M | 36 | 1943 | "At once" | Nov. 21, 1945 | 4.0 | Excellent | 1+ |
| 6 | G. E. M. (220473) | F | 63 | 1945 | "At once" | Dec. 14, 1945 | 3-4 | Excellent | 2 |
| 7 | J. M. C. (222424) | F | 45 | 1928 | 6 yr.* 12 yr.† | Feb. 2, 1946 | 1.5 | Excellent | 1+ |

*Until choledocholithotomy in 1934.
†Additional interval after choledocholithotomy.

remnant was ligated at its entrance into the common duct and excised. A T tube was left in the common duct for temporary drainage and decompression. At various intervals of time the tube was tied off and finally removed. Because of equivocal and sometimes misleading results postoperative choledochograms have not been used routinely by me and were not employed in any of this series.

The result in each of the seven patients was excellent after operation. All patients have been heard from recently, either by personal interview or letter, and none have had recurrent symptoms. The follow-up intervals vary between one and one-half and seven and one-half years.

## CASE REPORTS

CASE 1.—A. T. L., a man, aged 68 years, entered the University of Virginia Hospital July 3, 1939. He complained of recurring acute attacks of abdominal pain and jaundice during a period of twenty-six months. The attacks were at first spaced weeks or months apart, but during the preceding month had occurred every few days. Pain had been located in the right upper abdomen, had radiated to the right scapular region, had been severe, had required opiates for relief, and had been followed by residual soreness. Jaundice, highly colored urine, and clay-colored stools had been accompanying symptoms. He had lost sixteen pounds in three or four months. He stated that the attacks had been similar to those preceding an operation he underwent elsewhere in 1922 for the removal of a gall bladder containing numerous stones and removal of a stone from the common bile duct. Gall bladder symptoms, however, had appeared for the first time as early as 1912.

Pertinent physical findings were moderate icterus and a well-healed scar in the right upper abdomen with moderate tenderness in the region without muscle spasm or mass. Pertinent laboratory studies included an icterus index of 51 which in eighteen days fell to 9.7, bile in the urine, and both changed and unchanged bile in the stool.

The diagnosis, stone in the common bile duct, seemed obvious and operation was advised. The operation was performed July 24, 1939. Under spinal anesthesia with pontocaine the abdomen was explored through the scar of the previous incision. Adhesions following the former operation were not troublesome and general exploration was negative except as related to the common bile duct. It was moderately dilated but otherwise normal

except at its proximal part where a diverticulum-like pocket was discovered. This proved to be a cystic duct remnant dilated to more than 2 cm. in diameter. Just distal to it along the common bile duct there was a lymph gland more than 1 cm. in diameter. The common duct was incised just distal to the cystic duct remnant and careful exploration with probing and irrigation was negative for stone or other abnormality. Visualization of the papilla of Vater through an incision into the duodenum revealed nothing. The cystic duct remnant was excised and its communication with the common duct ligated. The adjacent lymph gland was removed and a T tube left in the common duct. Pathologically the cystic duct remnant showed chronic inflammation and the lymph gland chronic lymphadenitis.

Convalescence was uneventful and the patient was discharged from the hospital on the sixteenth postoperative day with the T tube still in place but tied off since the ninth day following its introduction. The tube was removed nine weeks after operation. A follow-up letter May 28, 1947, reported excellent health and no biliary tract symptoms from the time of removal of the cystic duct remnant, nearly eight years previously.

CASE 2.—L. T., a woman, aged 39 years, entered the University of Virginia Hospital Aug. 29, 1941. She complained of three attacks in eight months of acute abdominal pain. All attacks had been similar; acute, colicky pain in the epigastrium with some nausea and vomiting. There had been no radiation of the pain but its severity had necessitated the administration of opiates. Clay-colored stools and jaundice had been noticed. Nine years previously she had been operated upon elsewhere for "gall bladder trouble" but she did not know about the operative findings or procedures.

Physical examination revealed nothing more than moderate jaundice, and an old surgical scar in the right upper abdomen with tenderness and muscle spasm in the region. There was slight temperature elevation, and an icterus index of 31 was the only important laboratory finding. Because of uncertainty as to previous removal of the gall bladder the preoperative diagnosis was thought to be stone in the common bile duct with or without cholecystitis.

Operation was performed Sept. 3, 1941. Spinal anesthesia and an incision through the old scar were employed. Many adhesions were encountered and, therefore, only the upper abdomen was explored. The gall bladder had been removed and no abnormality was found except for a large bile duct about 1.5 cm. in diameter and a large cystic duct remnant dilated to more than 3 cm. in diameter. Careful exploration of the common duct by probing and irrigation through an incision into the duct just distal to the cystic duct remnant failed to reveal a stone or other abnormality. Graduated dilators up to the 8 mm. size passed readily into the duodenum. The cystic duct remnant was excised after ligating its attachment to the common duct and a T tube was left in the common duct. Pathologically the cystic duct remnant showed chronic inflammation.

Convalescence was uneventful and the T tube was tied off ten days after operation and removed fourteen days after operation. The patient left the hospital on the fifteenth postoperative day. A follow-up interview and examination April 9, 1947, showed freedom from symptoms referable to the biliary tract since removal of the cystic duct remnant more than five and one-half years previously.

CASE 3.—H. L. B., a woman, aged 73 years, entered the University of Virginia Hospital July 10, 1944. She complained of frequent pain in the epigastrium and back of three months' duration and jaundice of three weeks' duration. The pain had been more to the right of the midline, had radiated to the back in the scapular region, and usually had not been very severe. She had had similar pain without jaundice for one year preceding an operation elsewhere five years before. The gall bladder had been removed and found to contain "two small stones."

Physical examination revealed the scar of the operation, moderate jaundice, and what appeared to be slight enlargement of the liver. Laboratory studies showed bile in the urine, no bile in the stools, and an icterus index of 146. Obstructive jaundice due to probable stone in the common bile duct was diagnosed and operation advised.

Operation was performed July 19, 1944, under ether anesthesia. The scar of the previous incision through the upper part of the rectus muscle on the right side was excised and the abdominal cavity explored after separation of numerous adhesions. Nothing abnormal was found except in the common bile duct and its environs. Between 2 and 3 cm. of the cystic duct remained with evidence of scarring and thickening of it and of the adjacent common duct. The common duct was incised just proximal to this point and thoroughly explored by probing and irrigating it. No stone was found but there was some narrowing and thickening of the common duct where the cystic duct remnant lay in contact with it. Dilators were employed and passed readily into the duodenum. The cystic duct remnant was excised after its attachment to the common duct had been ligated and a T tube was left in the common duct. Pathologically the cystic duct remnant showed "fibrous scarring."

Convalescence from the operation was uneventful and the T tube was tied off twenty-four days after operation and the patient was discharged from the hospital Aug. 23, 1944. The icterus index twenty-seven days after operation was 68. The T tube was removed Oct. 16, 1944, and at that time the icterus index was 6.

Follow-up interview and examination Sept. 9, 1946, indicated entire freedom from biliary tract symptoms and no signs of abnormality in more than two years since removal of the cystic duct remnant. May 28, 1947, she reported continued freedom from symptoms, nearly three years after removal of the cystic duct remnant.

CASE 4.—J. H. C., a woman aged 28 years, entered the University of Virginia Hospital March 11, 1945. She complained of periodic attacks of severe pain in the upper abdomen on the right side since the age of 16 years, twelve years in all. The attacks had been interrupted for a period of only six weeks following cholecystectomy elsewhere two years before. She had been told there were stones in the gall bladder. Pain had been very severe, had required hypodermics for relief, and had been associated with nausea, vomiting, jaundice, and clay stools. Recently the attacks had been very frequent.

Examination was negative except for slight jaundice, the upper abdominal scar on the right side, and moderate tenderness in the region. Laboratory studies were normal except for an icterus index of 14 and a prothrombin time of 15 seconds with a control of 12 seconds. Operation was advised in the belief that there was probably a stone in the common bile duct.

Operation was performed March 21, 1945. Spinal anesthesia was employed and the abdomen explored through an incision coinciding with the previous one. No abnormality was found except in relation to the common bile duct. The duct was slightly dilated and seemingly within its adventitious coat there was a cystic duct remnant 2.5 cm. in length. The remnant spiraled partly around the common duct and entered its dorsal aspect. The common duct was incised ventrally and explored by probing and irrigating it. No stone, stricture, or other abnormality was discovered. Graduated dilators including one 7 mm. in diameter passed readily into the duodenum. The cystic duct remnant was ligated flush with the common duct and excised. The T tube was left in the common duct. Pathologically the cystic duct remnant showed "marked periductal fibrosis."

Convalescence was uneventful; the T tube was tied off eight days after operation and removed two days later. The patient was discharged from the hospital April 4, 1945, thirteen days after operation.

Follow-up by letter Sept. 1, 1946, nearly one and one-half years later, indicated that the patient had had no trouble and estimated as "perfect" the result of the operation for removal of the cystic duct remnant. Another follow-up report June 7, 1947, indicated freedom from biliary tract symptoms more than two years after removal of the remnant.

CASE 5.—M. G. W., a man aged 36 years, entered the University of Virginia Hospital Nov. 19, 1945. He complained of attacks of severe pain in the epigastrium during the previous one and one-half months and attacks of milder pain with much gaseous indigestion since June, 1943, a period of nearly two and one-half years. In June, 1943, he underwent operation elsewhere for removal of the gall bladder after suffering for nearly six months

with periodic attacks of typical acute gall bladder colic without jaundice. The gall bladder was said to contain three stones. Immediately following the operation not a week passed in which he did not suffer from marked indigestion with bloating and gas pains. Jaundice had been noticed occasionally. Attacks of very severe pain in the epigastrium with radiation to the scapular regions of the back similar to those suffered prior to cholecystectomy had occurred during the preceding one and one-half months. Clay-colored stools and jaundice had been noted by him. Some relief had been afforded only by hypodermics.

Examination was negative except for a well-healed surgical scar in the right upper abdomen with moderate tenderness and muscle spasm in the region and slight icterus. Laboratory studies were negative except for icterus indices varying between 37 and 17. Because of experience with the preceding cases in this series it was thought that the patient had either a stone in the common bile duct or a cystic duct remnant and operation was advised.

Operation was performed Nov. 21, 1945, under spinal anesthesia. This incision was made through the previous scar. General abdominal exploration was negative except for slight enlargement of the common bile duct and a cystic duct remnant 4 cm. in length lying along the right side of the common bile duct. The remnant was dissected free, ligated flush with the common duct, and excised. The common duct was incised distal to this point and explored by probing and irrigation and the passage of graduated dilators into the duodenum up to the 7 mm. size. No stone, stricture, or other abnormality was found. A T tube was left in the common duct. Pathologically the cystic duct remnant showed chronic inflammation.

Convalescence was uneventful. The T tube was tied off five days after operation and removed three days later. The patient was discharged from the hospital eleven days following operation. He reported by letter June 15, 1947, one and one-half years after removal of the cystic duct remnant, that he had been entirely relieved. He had only slight indigestion after retiring if he had eaten citrus fruits.

Case 6.—G. E. M., a woman, aged 63 years, entered the University of Virginia Hospital Dec. 3, 1945. She complained of attacks of pain in the upper abdomen toward the right during eleven months. She had commenced to have gall bladder symptoms in 1943 and underwent operation elsewhere March 23, 1945. The gall bladder, which contained "many calculi," was removed. For some weeks after operation she continued to have recurring attacks of sharp cramping pain in the epigastrium with radiation to the right and nausea and vomiting. Hypodermics were necessary to relieve pain and there was residual soreness. No jaundice and no clay stools were evident but urine was dark during attacks. The attacks, however, ceased for about six months but reappeared and became more severe and frequent during the two months preceding hospitalization.

Examination was essentially negative except for some tenderness in the region of the surgical scar in the right upper abdominal wall and some icterus. Laboratory studies were normal except for icterus indices varying between 19 and 68. Stone in the common duct or cystic duct remnant was suspected and an exploratory operation was advised.

Operation was performed Dec. 14, 1945. Spinal anesthesia was employed and the incision was made through the scar in the right upper abdomen. There were so many dense adhesions that only the upper abdomen was explored. Nothing abnormal was found except for dilatation of the common duct to a diameter of approximately 1.5 cm. and a cystic duct remnant more than 3 cm. in length. The common duct was incised and explored by probing and irrigation without discovering stone, stricture, or any other abnormality. Graduated dilators including one 7 mm. in size passed readily into the duodenum. The cystic duct remnant was ligated at its entrance into the common duct and excised. A T tube was left in the common duct. Pathologically the cystic duct remnant showed chronic inflammation and a little sandlike material within its lumen distally.

Convalescence was uneventful after operation and in four days the T tube was tied off and in four more days it was removed. The patient was discharged from the hospital fourteen days after operation. Follow-up through Dec. 16, 1947, revealed freedom from biliary tract symptoms for two years after removal of the cystic duct remnant.

CASE 7.—J. M. C., a woman, aged 45 years, entered the University of Virginia Hospital Jan. 31, 1946. She complained of attacks of pain in the right upper abdomen, three during the preceding six weeks. Pain had been severe with radiation to the right scapular region and with nausea and vomiting. Jaundice had occurred, hypodermics had been necessary for pain control, and there had been residual soreness. She referred to two previous operations performed elsewhere, one in 1928 for removal of a "strawberry gall bladder" and one in 1934 for removal of stones from the common bile duct.

Examination was negative except for slight tenderness in the region of a surgical scar in the right upper abdominal wall. There was no jaundice and laboratory studies were normal. Stone in the common duct or a cystic duct remnant was suspected and operation advised.

Operation was performed Feb. 2, 1946. Spinal anesthesia was employed and the incision was made through the scar of the previous right upper abdominal incisions. No abnormality was found except for slight enlargement of the common bile duct, which was a little more than 1 cm. in diameter, and a cystic duct remnant 1.5 cm. in length. The common duct was incised and explored by probing and irrigation but no stone or other abnormality was found. Graduated dilators up to 6 mm. in diameter passed readily into the duodenum. The cystic duct remnant was ligated flush with the common duct and excised. A T tube was left in the common duct. Pathologically the cystic duct remnant showed chronic inflammation.

Convalescence was uneventful and the T tube was tied off four days after operation and five days later was removed. The patient was discharged from the hospital on the thirteenth postoperative day. Follow-up interview and examination Oct. 9, 1946, eight months after operation, revealed complete freedom from biliary tract symptoms and signs. Re-examination Sept. 22, 1947, revealed no trouble more than one and one-half years after removal of the remnant.

## COMMENT

Seven instances of cystic duct remnant presumably solely responsible for symptoms in patients previously subjected to cholecystectomy elsewhere, have been described. In two others, not reported, a cystic duct remnant was probably related to postcholecystectomy symptoms. The cases occurred in a period of only seven years and in the experience of a single surgeon. Although these patients sought surgical treatment because of the severity of the symptoms, it is probable that others with similar trouble did not seek operation because of less severe symptoms. It seems likely, therefore, that a cystic duct remnant may be a frequent source of postcholecystectomy symptoms.

In reporting a uniformly excellent result in all of the cases it is realized that the follow-up interval is possibly too short to insure permanent freedom from biliary tract symptoms. The symptoms attributed to the cystic duct remnant did not appear in recognizable degree until from fifteen years to immediately following cholecystectomy. The follow-up periods vary from nearly eight years to over one and one-half years (Table I).

Surgical literature abounds in technical discussions of cholecystectomy but in referring to division of the cystic duct in the course of cholecystectomy the emphasis is on avoidance of common duct injury with little, except in very recent years, to indicate that leaving some of the cystic duct may cause trouble. An extreme example is found in one of several texts consulted.* In the description of cholecystectomy the statement occurs in referring to division of the cystic

*Not referred to in the Reference list.

duct—"It should not be clamped until it has been clearly isolated close to the gall bladder."

Because of the serious consequences of injury to the common duct every precaution should be observed to protect it, but this attitude should not cause one to leave a cystic duct remnant which, as shown by the cases of this report and others, may cause symptoms and necessitate another operation with its attendant magnified risks and dangers.

Anatomically the cystic duct has been said to "average 2.5 cm. in length" and to follow a downward course, "parallel to the hepatic duct on its right, and anterior surface for a variable distance before it actually emptied into the latter to form the common bile duct."[2] Actually variations of the cystic duct are extreme, both as to length and as to course. Graham and associates[4] reported at length the variations in the extrahepatic ducts and adjacent blood vessels. Four pages of text and thirty diagrams illustrate various abnormalities in the arteries and the extrahepatic bile ducts met with in gall bladder surgery. These and other considerations formidably support the statement of Hicken and co-workers,[6] "Experience dictates that no physician should elect to operate on the gall bladder unless his training and familiarity with the biliary system will permit him to explore the large bile ducts and correct complicated intraductal problems."

I have been impressed by the frequency with which the cystic duct is so intimately associated with the common duct that they seem to be encompassed by a common adventitial covering, and also by the fact that the cystic duct not uncommonly follows a spiral course along much of the circumference of the common duct and enters it dorsally rather than ventrally or laterally as in most instances. Graham and associates called attention to these as well as many other variations.

As to the mechanism by which a cystic duct remnant may cause symptoms, various authors differ. Beye[1] thought the dilatation of the remnant and the re-formation of a gall bladder-like diverticulum is important. Ivy and Sandblom[7] and others believed the influence of the choledochoduodenal mechanism of reciprocal innervation is important. Womack and Crider[9] referred to the neuroma-like scarring associated with the remnant, and Macdonald[8] stressed the focus of infection resident in the remnant.

It seems possible that the close anatomic juxtaposition of the cystic and common ducts may offer the simplest explanation of the mechanism by which a cystic duct remnant left in the course of cholecystectomy causes clinical manifestations. The equally diseased duct remains after the diseased gall bladder has been removed. The valves of Heister and the tangential implantation of the cystic in the common duct promote stasis and harbor or invite infection. Periodic exacerbations of the infection with edema and possibly some resultant extraneous obstruction of the adjacent common duct may, with or without an accompanying widespread cholangitis and hepatitis, explain the pain and jaundice which are the characteristic clinical manifestations attributed to a cystic duct remnant.

SUMMARY

Among the causes of postcholecystectomy symptoms a cystic duct remnant has been referred to previously but accorded inadequate general attention. This report records the cases of seven patients in whom the remnant appeared to be the sole cause of symptoms and refers to two additional cases in which the remnant seemed to play a contributory part. After consideration of anatomic and technical aspects the conclusions seem definite that (1) a cystic duct remnant may frequently be a source of postcholecystectomy symptoms and that (2) meticulous care should be exercised at the time of cholecystectomy to remove the entire cystic duct.

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# VASCULAR THROMBOSIS IN ACUTE APPENDICITIS

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IN THE histologic examination of appendices removed in cases of acute appendicitis, thrombosis of small vessels occasionally has been noted. This study was undertaken to determine the origin and frequency of occurrence of thrombi and, if possible, their relationship to the course of the disease.

Modern texts on surgery and pathology make little or no mention of the occurrence of thrombosis in acute appendicitis. While the literature on acute appendicitis is voluminous and includes several thousand articles, the vascular factor in this disease has received comparatively little attention.

Aschoff's[1] views on the pathogenesis of acute appendicitis are the basis of present-day teaching. Aschoff's monograph makes little reference to vascular lesions or circulatory disturbances. These were regarded as purely secondary to acute appendicitis.

Van Cott, in the chapter on pathology in Fowler's[2] monograph on appendicitis, described paravasculitis, perivasculitis, endovasculitis, and thrombosis of the mesenteric vessels and concluded that torsion of the mesentery resulted in vascular and nervous degenerative changes that caused interference with the nutrition of the appendical tissues and thus opened the way to infection.

De Klecki[3] insisted on the importance of circulatory disturbances as an etiologic factor in appendicitis in man and stated the belief that such disturbances might follow kinking or torsion of the appendix or its mesentery.

Meisel[4] found frequent vascular lesions of the meso-appendix and stated the belief that these were of primary significance in appendicitis. Von Brunn[5] found thrombotic or obliterating vascular lesions in all but one of twenty cases of appendicitis. He disagreed with Meisel, however, as to their significance, and stated that he thought them secondary rather than primary to the infection.

Graham[6] suggested that the reason for the frequency of occurrence and the occasionally rapid destructiveness of appendicitis is interference with the circulation of the appendix, which is of the terminal or peripheral type and is peculiarly exposed to mechanical blockage by angulation, kinking, or torsion. He added that internal concretions may readily produce stasis of the blood stream.

Modern thought concerning the cause of acute appendicitis is in accord with the teachings of Aschoff; however, as a result of the work of Wangensteen and his associates[7, 8] the importance of appendical obstruction in the pathogenesis of acute appendicitis now is recognized.

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Vascular thrombosis was noted by John Hunter[9] in veins passing through inflamed tissues. In a paper read in 1784 he described the walls of veins as being adherent and stated that the adhesions arose from "the extravasation of coagulable lymph . . . thrown out by the exhalants on the internal surface of the vein."

Bell[10] has mentioned the importance of infection in the production of thrombosis. The suppurative process may extend to the vessel and cause injury to the vascular endothelium. Modern textbooks of pathology[10-13] agree that thrombosis starts as the deposition of blood platelets on a roughened area of intima. Endothelial damage, slowing of the blood stream, and changes in the composition of the blood are cited as the causes of thrombosis.

## MATERIAL AND METHOD OF STUDY

Histologic studies were made on 100 appendices removed in consecutive cases of acute appendicitis. The appendix in each case had been fixed in formalin immediately after removal. The organ was cut transversely and examined grossly for areas of necrosis or perforation. Multiple sections were cut in this manner throughout the entire length, about three sections being made to the centimeter. Blocks were then cut from any part which presented gross evidence of necrosis or from representative parts of the appendix. Three to five blocks were made from each appendix and the blocks were sectioned and stained with hematoxylin and eosin for microscopic examination.

The criterion for thrombosis in the specimens examined was the presence of fibrin and fibrocytes within a vessel whose walls could definitely be identified. This eliminated the identification of any of the various types of capillary thrombosis differentiated by Aschoff[14] and others.[15-17] However, this strict standard was necessary, as positive identification of thrombosis in small vessels and capillaries is impossible in specimens in acute appendicitis in which exudation of protein material and the presence of cells and detritus within the tissue spaces of the organ are evident.

The clinical history then was reviewed in each case and the age, sex, duration of symptoms, and the leucocyte count were noted as well as the postoperative course of the patient.

## RESULTS OF INVESTIGATION

Evidence of thrombosis was found in one or more vessels in twenty-six of the 100 appendices examined. In nine of these twenty-six specimens the thrombosis occurred only in arteries. In twelve specimens the thrombosis occurred only in veins and in five specimens it occurred in both arteries and veins. At sites of thrombosis there did not appear to be any more marked inflammatory reaction in the tissues immediately surrounding the vessel than in the adjacent areas.

Most of the thrombi were at an early stage of development and all occurred in small vessels from 100 to 800 microns in diameter (Figs. 1 and 2, *a* and *b*). Recanalization was found in one case. This occurred in a girl 11 years old who gave a history of acute appendicitis of sixty hours' duration.

In six appendices only one thrombosed vessel was found in each. The greatest number found in any one specimen was ten and the average number found per organ of the twenty-six which contained thrombosed vessels was 3.3.

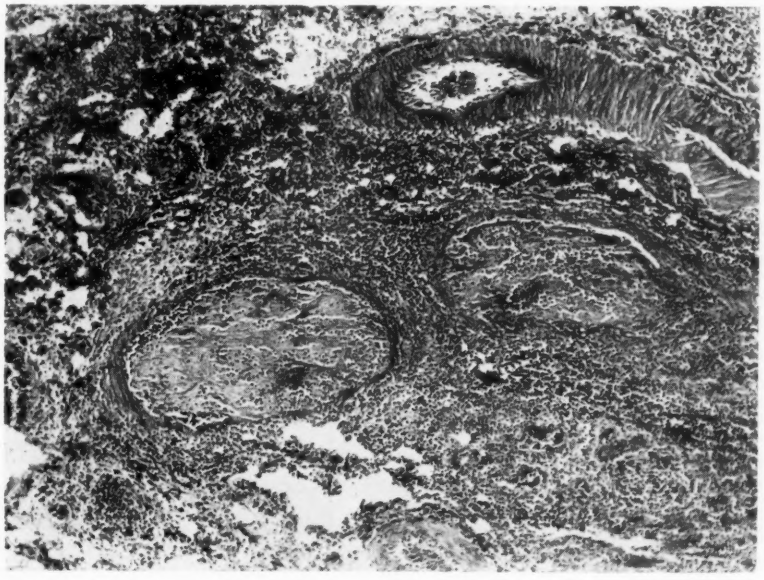

Fig. 1—Early thrombosis of a venule cut in longitudinal section (hematoxylin and eosin ×70).

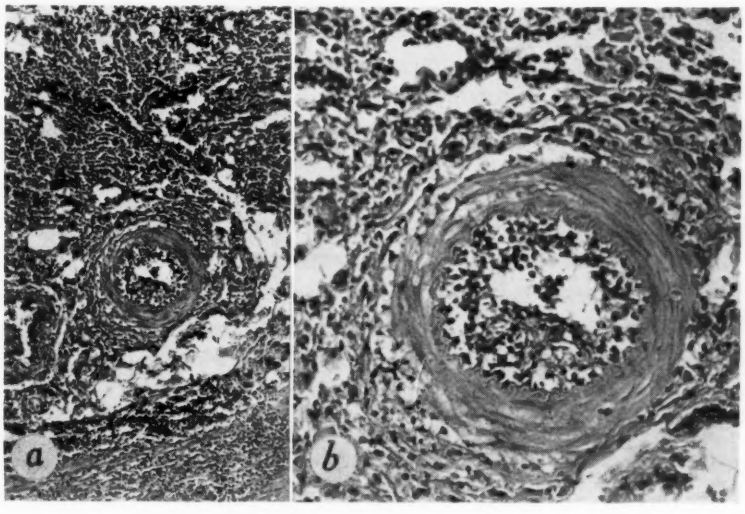


Fig. 2.—Thrombosis of an arteriole in the submucosa (hematoxylin and eosin, *a*, ×70; *b*, ×200).

Of the eighty-seven thrombosed vessels seen, sixty-four were in the submucosa, twenty-two in the subserosa, and one in the muscularis. The majority of thrombosed vessels were seen in the distal third of the appendix.

Gangrene, rupture of the appendix, and fecaliths were found more frequently in the group of specimens with thrombosed vessels than in the group of specimens without thrombosis (Table I).

TABLE I. INCIDENCE OF GANGRENE, RUPTURE OF THE APPENDIX, AND FECALITHS IN APPENDICES WITH AND WITHOUT THROMBOSED VESSELS

| | WITH THROMBOSIS (26 CASES) | | WITHOUT THROMBOSIS (74 CASES) | |
|---|---|---|---|---|
| | CASES | PER CENT | CASES | PER CENT |
| Gangrene | 15 | 57.7 | 20 | 27.0 |
| Rupture | 5 | 19.2 | 4 | 5.4 |
| Fecalith | 13 | 50.0 | 15 | 20.3 |

Data regarding the duration of symptoms, leucocyte count, and age of patients who had appendicitis with and without thrombosed vessels are given in Table II. There were two children 4 years of age who had thrombosis of the appendical vessels. One child was 8 years old and three were 9 years old. The oldest person who had thrombosis of the appendical vessels was 65 years old.

Fifty-four per cent of the patients in the group with thrombosis and 46 per cent in the group without thrombosis were males.

TABLE II. DATA ON DURATION OF SYMPTOMS, LEUCOCYTE COUNT, AND AGE OF PATIENTS WHO HAD APPENDICITIS WITH AND WITHOUT THROMBOSED VESSELS

| | WITH THROMBOSIS (26 CASES) | WITHOUT THROMBOSIS (74 CASES) |
|---|---|---|
| Average duration of symptoms (hours) | 36 | 33 |
| Average leucocyte count | 18,300 | 14,300 |
| Average age (years) | 22.0 | 23.2 |

One abscess in the operative wound developed postoperatively in the group with thrombosed vessels and three abscesses in the wound and one in the pelvis occurred in the group in which thrombosis was not found.

## COMMENT

It is apparent that the evidence of thrombosis found in the specimens examined in this study was secondary to acute appendicitis. This can be concluded from several findings: (1) wherever evidence of thrombosis was found it was minimal and was present in an extremely small fraction of the total number of vessels in each section; (2) the thrombosed vessels were very small; (3) the surrounding inflammatory reaction was no more marked in the immediate vicinity of the thrombosed vessel than in the adjacent areas.

The element of time also supports the view that the thrombi found in this study were secondary to acute appendicitis. The duration of symptoms averaged three hours longer in cases in which thrombi were present than in cases in which thrombi were absent.

The majority of thrombosed vessels were found in the submucosa. Although the circulation is of the terminal or peripheral type, the vessels anastomose freely.[18] Koster and Weintrob,[19] from their experimental studies, commented on the richness and profuseness of anastomosis and showed that the blood supply is in two layers, of which the richer is the deeper or submucosal layer. The fact that the majority of the thrombosed vessels were in the freely anastomosing submucous layer probably contradicts the notion that the thrombosis was caused by stagnation of the flow of blood.[14] Rather, the thrombosis occurred as a result of endothelial damage and extension of the surrounding inflammation.

Thrombosis is thought to occur more frequently in older people. This apparently is not true of thrombosis which occurs in the vessels of acutely inflamed

appendices; thus, in this series the average age in the cases in which thrombosis occurred was nearly the same as that in cases in which thrombosis did not occur (Table II). In two cases in which thrombosed vessels were found the patients were 4 years of age.

The higher average leucocyte count in the group with thrombosed vessels as compared with that in the group without thrombosis can be explained in part, at least, by the longer duration of symptoms before removal of the diseased appendix in the former group (Table II). The higher incidence of gangrene and rupture in the group with thrombosis also explains the higher leucocyte count.

It is supposed that the longer duration of the disease in the group with thrombosed vessels as compared to the group without thrombosed vessels partly explains the higher incidence of gangrene and rupture in the group with thrombosis (Table II). This supposition is supported by the fact that the average duration of symptoms in cases of gangrene or rupture in both groups of cases was forty-three hours.

The incidence of fecaliths in the cases in which thrombosed vessels were found was considerably higher than that in the cases in which thrombosis was not found (Table I). This should not be interpreted to mean that the presence of fecaliths directly influences the production of thrombosis. The relationship is undoubtedly indirect. Tennison and Dixon[20] have shown from a study of 1,954 cases of appendicitis that the incidence of gangrene in appendicitis is higher in the presence of fecaliths. The presence of thrombosed vessels in acute appendicitis appears to be dependent, to an extent, on the duration of symptoms and the severity of the disease.

The significance of thrombosed vessels in acute appendicitis cannot be determined with definitiveness. Gangrene of any tissue is due directly to interference with its blood supply. The indirect cause may be infection or pressure which in turn brings about the impairment of the blood supply to the tissue. The presence of gangrene and rupture in a much higher percentage of appendices with thrombosed vessels than in those without thrombosis cannot be disregarded. It may be assumed from the higher incidence of thrombosed vessels in gangrenous than in nongangrenous appendices and from the very nature of gangrene itself that most gangrenous appendices would be found to contain thrombosed vessels if serial sections were made from such specimens.

The question of pylephlebitis as a complication of acute appendicitis arises in any consideration from thrombosis that occurs in appendicitis. Hawkes[21] stated that in certain acutely inflamed appendices there is rapid death of the part with the formation of a protective thrombus in the venous radicles. He further stated that the thrombus may extend upward if it is not removed or isolated at the time of operation. In a study of 1,463 cases of appendicitis he found twenty-four cases in which the complication of pylephlebitis occurred, with a death rate of 33 per cent in these twenty-four cases. Colp[22] recommended ligation of the ileocolic vein just before the appendix is removed if a diagnosis of pylephlebitis has been made.

In this series of cases there was no relationship between the presence of thrombosed vessels and the postoperative course of the patient.

SUMMARY

Histologic study of sections of 100 appendices in cases of acute appendicitis to determine the incidence of vascular thrombosis has been made along with a study of the histories in each case. Thrombosis was found in 26 of the 100 specimens studied. Eighty-seven thrombosed vessels were found; all were small vessels. The thrombosis appeared to be secondary to the acute appendicitis and dependent, to an extent, on the severity of that disease.

Evidence from this study suggests that thrombosed vessels would be found in most gangrenous appendices if serial sections were made and examined.

Pylephlebitis that occurs with acute appendicitis may have its origin in a thrombosed vessel of the diseased appendix.

In this series there was no relationship between the presence of thrombosed vessels within the appendix and the postoperative course of the patient.

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# THE ROENTGEN DIAGNOSIS OF VOLVULUS OF THE CECUM

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VOLVULUS of the cecum is generally regarded as a rare cause of intestinal obstruction. Yet on the basis of incidence alone it is of sufficient importance to be considered in all cases of acute and recurring types of intestinal obstruction.

The first case of volvulus of the cecum was reported by Rokitansky[29] in 1841. Following that, no thorough consideration of the condition appeared until the work of Monteuffel,[25] who reported 24 cases in 1898. Faltin,[9] in 1902, collected 79 cases including those just mentioned. By 1913 Bundschuh[2] was able to collect some 110 cases and in 1942 Wolfer, Beaton, and Anson[36] collected an additional 193 cases making a total of 304. Of these 193 cases, 40 occurred in North America. Since that time a few cases have appeared in the literature each year.

Volvulus of the cecum is commonly a disease of young adults, 50 per cent of Corner and Sargent's[5] patients being between the ages of 20 and 40 years. Eighty-four per cent of Bundschuh's[2] patients were under 40 years of age, and in the series reported by Faltin,[9] 45 per cent were between the ages of 17 and 30 years. Nevertheless, the condition may occur at any age. The youngest case reported was in an infant of 10 months, the oldest one in a man of 89 years. The four cases which we are reporting were all in patients over 50 years of age. Volvulus of the cecum occurs more frequently in males than in females, the ratio being more than two to one. In our own series all of the cases were in males. It would appear from a consideration of the cases reported in the literature that this condition may be the causative factor in approximately 1 per cent of all the cases of intestinal obstruction.

The designation, volvulus of the cecum, is misleading as in almost all of the cases a variable amount of the terminal ileum and ascending colon are usually involved. A better term might be volvulus of the right half of the colon. The site of torsion may be anywhere from the cecum to the splenic flexure. The axis of rotation may be transverse, oblique, or parallel to the long axis of the cecum and the ascending colon. In most cases the rotation is in a clockwise direction. Here, as in other portions of the bowel, a torsion of 180 degrees is usually considered sufficient to produce obstruction. Further twisting will lead to strangulation. It is, however, impossible to demonstrate a physiologic volvulus, without obstruction, with a rotation of only 180 degrees.

Volvulus of the cecum may result from either anatomic or functional causes. Usually it occurs only in the presence of an abnormal mobility of the cecum

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and ascending colon which is present in approximately 10 to 15 per cent of adults. Such abnormal mobility is a result of failure of fusion or fixation of the posterior cecal mescolon to the parietal peritoneum of the posterior abdominal wall. Other anomalies which are found with volvulus of the cecum are a long mesocolon and mesocecum, a common ileocecal mesentery, retroperitoneal ileum and malpositions of the cecum including inversion, left-sided position, and reversed rotation.

Functionally both stasis and hyperperistalsis have been predicated as precipitating factors. Other factors frequently mentioned are high residue diet, violent exercise, pregnancy, and tumors.

Volvulus of the right half of the colon occurs frequently enough following abdominal surgery to be worthy of particular mention. One of our patients developed the condition subsequent to a subtotal gastrectomy. Other cases have been reported in the literature in which the lesion apparently followed a surgical procedure on the abdomen.

Two clinical types of volvulus of the cecum occur—the acute and the recurrent. The symptoms are those of acute mechanical bowel obstruction with vomiting, abdominal cramps associated with borborygmi, abdominal distention, and obstipation occurring. Physical examination reveals moderate tenderness over the massively dilated cecum which may be found in an ectopic position. Signs of peritoneal irritation are usually absent unless the process has gone on to infarction with peritoneal contamination. The attack may relent spontaneously under nonoperative therapy only to recur again at a later time. In the recurrent type symptoms may simulate acute appendicitis and patients have been operated upon under that diagnosis, only to find a volvulus of the cecum at operation.

The preoperative diagnosis of volvulus of the right half of the colon has been made very infrequently in the past. The possibilities of roentgen examination as a means of making this diagnosis have been recognized and in the light of our experience there is no doubt that this may be the most important single factor in determining the presence of the condition.

Roentgen examination of the abdomen in such situations may be accomplished with or without the use of contrast material. The diagnosis of volvulus of the sigmoid has been reported on many occasions. It is particularly well demonstrated by means of the barium enema, as was shown by Laurell[21] in 1926. He demonstrated the twisting of the sigmoid colon up to 180 degrees by means of the visualization of the mucous membrane pattern. At the same time he showed that a film of the abdomen, without the use of contrast material, ofttimes will reveal the site of the obstruction and that the mucosal pattern may be delineated in the adjacent bowel by contrast with the gas which is present.

In 1937 Easton and Adams[8] made a preoperative diagnosis of volvulus of the cecum by means of a barium enema. They postulated that two conditions indicated the presence of a volvulus of the cecum. The first was an obstruction to the passage of barium by enema at a certain point in the ascending or transverse colon; the second was the simultaneous presence of a large

collection of gas at the site of the cecum, either in the midline or slightly to the right of it. It was necessary, however, to exclude an organic lesion such as a carcinoma. Jackobsen[18] in 1945 stated that the typical roentgenogram of cecal volvulus shows a greatly distended cecum varying in size, with one or, less commonly, two fluid levels shown with the patient erect or in the lateral decubitus position. Fluid levels are also found in the small bowel. The barium enema will stop at the point of torsion and there is generally seen a typical mucosal pattern indicative of twisting. Roentgen findings have been recently reported by Young, Morrison, and Wilson.[37]

During the past year we have seen three cases of volvulus of the cecum in which the diagnosis was made preoperatively. In addition we observed one case in 1944 in which the diagnosis was suspected but not established until abdominal exploration was undertaken. On the basis of these cases we feel that the criteria for diagnosis are present in the simple film of the abdomen and that the barium enema is not an absolutely necessary diagnostic procedure although it may be very helpful to confirm positively the suspected diagnosis.

The findings in the simple film of the abdomen are as follows: (1) the cecum is greatly dilated and appears to lie in an ectopic position; (2) loops of small bowel may be seen distended with gas, often lying to the right of the distended cecum; (3) the ileocecal valve may be demonstrable lying to the right of the distended cecum; it will give a distinct shadow in contrast with the gas in the cecum surrounding it and in the small bowel within it; (4) the spiral distortion of the mucous membrane folds may sometimes be seen at the site of twisting, being visible because of contrast with the gas in the bowel; (5) there is usually a considerable dilatation of the small bowel, with fluid levels seen in the upright position, suggesting a small bowel obstruction; this results from the relatively proximal position of the obstruction in the colon. Differentiation from volvulus of the sigmoid, organic obstruction of the transverse or sigmoid colon due to carcinoma, and adynamic ileus must be accomplished. Obviously if the site of obstruction can be seen this tends to make the differential diagnosis clear. If the site of obstruction is clearly delineated in the left lower quadrant, volvulus of the cecum can be ruled out fairly well. Usually with volvulus of the sigmoid there is little or no distention of the small bowel. Often the distended loops of sigmoid can be easily identified rising up out of the pelvis either to the right or left and the point of torsion may be seen. In most instances of volvulus of the sigmoid two fluid levels are seen in the upright position.

The utilization of the barium enema is advisable where a serious difficulty in differentiation occurs. When given with care there is little or no danger and the exact site of obstruction or torsion of the colon may well be demonstrated, making the diagnosis perfectly definite.

The differential diagnosis from adynamic ileus may present some difficulties. Usually in adynamic ileus one has a silent abdomen in contrast to the cramps and borborygmi found with volvulus. Roentgenologically in adynamic ileus there is generalized distention of both the large and small bowel but this does not necessarily follow as irregular accumulations of gas may occasionally

occur. The cecum can usually be seen to be in normal position and fluid levels are much less common. The small bowel does not show the usual hairpin turns characteristic of a dynamic type of obstruction but even this is not completely a differential point. The particular factor of a markedly distended cecum without corresponding distention of the remaining portion of the colon should lead at once to the suspicion that there is a real obstruction in the ascending colon rather than an adynamic ileus. The extent of the small bowel distention is usually greater in adynamic ileus than it is in a volvulus.

The following four cases are reported as illustrations of the findings in this condition.

## CASE REPORTS

CASE 1.—D. J., a white man, physician, aged 48 years, was admitted to the University Hospital Aug. 20, 1946, with a twenty-year history of duodenal ulcer. An elective gastric resection was done on Aug. 21, 1946,* without untoward event. An appendectomy was also done and an unusual mobility of the cecum was observed at this time. The immediate postoperative course was normal. However, when the patient began to ingest food there was some distention of the abdomen. No vomiting or colic was present but there was lively peristalsis present throughout the abdomen. Bowel movements were minimal or almost absent. The patient was ambulatory and complained very little but the failure to develop a normal bowel movement and the distention of the abdomen gave considerable concern.

The first roentgen examination of the abdomen made Aug. 29, 1946 (Fig. 1), just eight days after the operation, showed all of the findings most adequately although these were not recognized at once. A tremendously distended hollow viscus could be made out lying somewhat to the left of the midline, having much the shape of the cecum and ascending colon. It measured approximately 15 cm. in diameter. In addition, there was seen a collection of distended loops of small bowel lying to the right of this viscus and extending up to it. Further observation twelve hours later with additional films brought home the fact that the ileocecal valve was perfectly apparent just overlying the spine and it was identified by reason of the gas-filled loop of small bowel which remained between the two lips and by the gas which surrounded the valve in the greatly distended cecum. The position of the cecum and ascending colon lying on the left side, with the ileocecal valve lying to the right, and the distended loops of small bowel extending to the right of it, together with very little gas shown in the remaining colon, gave clear diagnostic evidence of volvulus. In order to make absolutely certain, a barium enema was done twelve hours after the original examination. The findings as to the gas-filled cecum and the small bowel were almost identical on this roentgenogram (Fig. 2) in which the ileocecal valve was even more clearly delineated just to the right of the spine. The barium enema met an obstruction at a point just proximal to the hepatic flexure and the characteristic twisting of the mucosal folds was made out thus clinching the diagnosis of volvulus of the cecum and ascending colon.

A laparotomy was performed* and an enormous cecum measuring 24 cm. in length and 15 cm. in diameter was found. Although the bowel was viable, serosal splitting of the cecum from the extreme dilatation had already occurred so that an excision of the cecum and 20 cm. of the terminal ileum was done and an oblique end-to-end anastomosis between the ileum and ascending colon accomplished. Before excision a decompressive suction enterostomy was accomplished and several hundred cubic centimeters of fecal material were removed from the small intestine. An aseptic catheter enterostomy in the distal ileum done after the technique of Wangensteen[35] was performed and was brought out through the abdominal wall above the incision. The postoperative course was marked by some distention for the first week. The enterostomy tube was removed at the end of the second week and the patient was discharged completely well on Sept. 21, 1946.

*By Dr. O. H. Wangensteen.

*Comment.*—This case illustrates better than any of the rest the striking and characteristic findings, particularly the malposition of the cecum, the abnormal position of the ileocecal valve, and the distention of the small bowel without much distention of the colon. The characteristic findings on barium enema examination are also clearly delineated.

Fig. 1.

Fig. 2.

Fig. 1 (Case 1).—Roentgenogram of the abdomen eight days after gastric resection and three days after the onset of distention. The enormously distended cecum can be made out lying well to the left of the midline and extending down into the pelvis. To the right of the cecum the ileocecal valve is apparent. It presents dense, linear shadows in contrast with the surrounding gas in the colon. Extending from the ileocecal valve to the right the terminal portion of the ileum is clearly delineated by reason of the gas within it and the distended loops of small bowel are seen extending up into the right upper quadrant. The twisted mucosal folds in the colon can also be seen in the original films. There is a small amount of gas in the descending colon and some gas is also seen in the remaining portions of the ileum. Largely on the basis of this examination the diagnosis was predicated.

Fig. 2 (Case 1).—Barium enema examination in the same case. The findings observed in the simple film of the abdomen are again shown here. In addition, the point of obstruction in the ascending colon is clearly delineated and the twisted mucous membrance folds are seen just at the end of the barium column.

CASE 2.—G. A. D., a white man, aged 87 years, was admitted to the University Hospital on Dec. 30, 1944. Eight hours prior to admission he began to have crampy, lower abdominal pains with development of retching but no vomiting. He had had a bowel movement on the day of admission and had passed flatus after receiving three enemas before admission. He had a long past history with gastric distress since the age of 19. A diagnosis of peptic ulcer had been made in 1932.

In 1939 the patient had a left pelviolithotomy at which time a roentgenogram (Fig. 3) of the abdomen made in the course of an injection of the left kidney pelvis showed distended large bowel on the right side in a very peculiar position. The significance of this was not fully appreciated at that time but it is evident from an examination of the film that the abnormal mobility of the cecum, its position being high in the right abdomen, was present at that time.

Fig. 3.

Fig. 4.

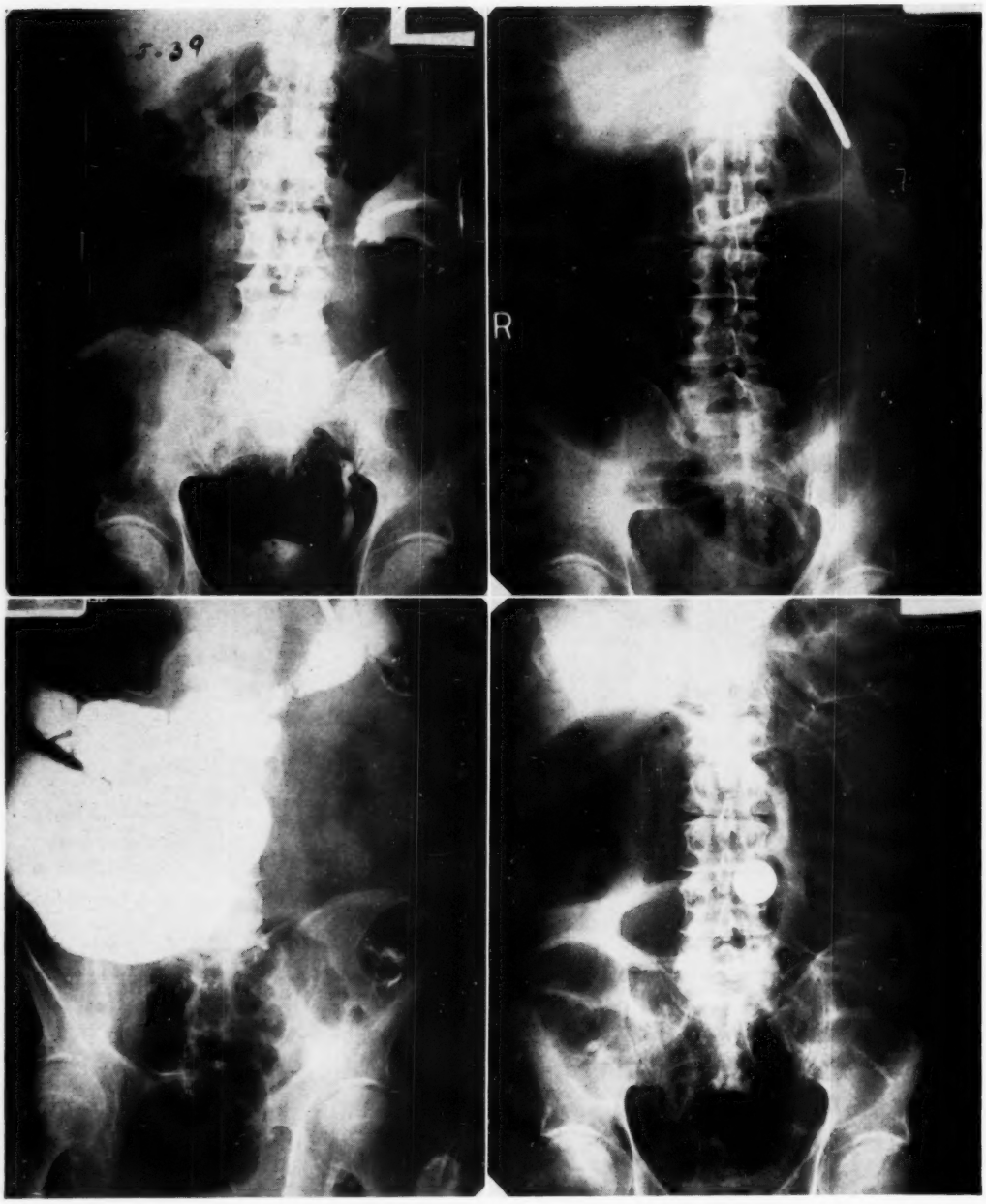


Fig. 5.

Fig. 6.

Fig. 3 (Case 2).—Roentgenogram of the abdomen, Feb. 5, 1939, made after pelviolithotomy on the left side. A drainage tube and contrast media in the left kidney pelvis and ureter are seen. The cecum can be made out here as a distended loop of bowel lying parallel to the transverse colon with its base well over toward the midline.

Fig. 4 (Case 2).—Simple roentgenogram of the abdomen made after gastric resection. A suction tube is shown in the remaining portion of the stomach. Note the enormously distended cecum and ascending colon. The tip of the cecum lies well to the left of the midline and the long axis of the cecum is parallel to the transverse colon. There is, however, marked distention of the remainder of the colon so that the degree of obstruction at this time could not have been high grade but the abnormal position of the cecum indicates the basis for a volvulus.

Fig. 5 (Case 2).—Same case at about the same time after attempted barium enema examination. Again the abnormal position and distention of the cecum are clearly delineated.

Fig. 6 (Case 2).—Roentgenogram of the abdomen after admission of the patient for an acute abdominal condition. The small bowel is greatly distended and lies largely on the left side of the abdomen. There is very little gas in the distal colon. The greatly dilated cecum and ascending colon can be clearly made out. The tip of the cecum extends to the left of the midline while the position of the ascending colon is very abnormal. A volvulus was present at this time although the diagnosis was not recognized from the roentgen study.

In 1941 the patient had another attack of hematemesis and melena. In March, 1943, he was admitted with a history of nausea and vomiting, abdominal pain, and no bowel movements for three days. At that time a diagnosis of a perforated viscus was made but operation was refused and the patient subsequently developed a right subdiaphragmatic abscess which was drained followed by a relatively uneventful convalescence. In January, 1944, the patient was again admitted for hematemesis and melena. Because of these numerous episodes of bleeding, some of which endangered the life of the patient, he was readmitted to the hospital in June, 1944, and, ulcers of the stomach and duodenum having been found, a subtotal gastric resection was done.* Postoperatively the abdomen showed marked distention and on one occasion the film of the abdomen showed an enormous dilatation of the cecum which extended well beyond the midline to the left (Fig. 4). A barium enema examination was done on the same day (Fig. 5). There was angulation of the ascending colon with dilatation of the cecum which was considered due to a malposition of the cecum and some spasm. Without further treatment the distention gradually receded and the patient was discharged the middle of July, 1944.

He had no further difficulty until admission six months later. On this occasion there was moderate distention of the abdomen with a visible and palpable mass in the right upper quadrant. Marked tympany was present on percussion and bowel sounds were active. A simple film of the abdomen (Fig. 6) revealed the cecum or ascending colon enormously distended by gas in the right upper quadrant. There was, in addition, marked distention of the remaining portions of the colon and considerable distention of the small bowel. The exact nature of the process was not appreciated. Re-examination made eighteen hours later showed persistence of this tremendous distended loop of bowel and an obstruction of the colon was predicated but the exact nature of the process was not realized until operation. He was operated upon† Dec. 31, 1944, at which time a volvulus of the cecum was found with the torsion estimated to be 360 degrees. Gangrene of the bowel was already present. An obstructive Mickulicz type of exteriorization with resection of the cecum and right colon was performed. The postoperative course was uneventful except for slight postoperative dehydration. The patient was discharged Jan. 21, 1945, and readmitted in March for closure of the ileocolostomy which was done March 19, 1945, with an uneventful convalescence.

*Comment.*—This was the first of the patients which we saw and a diagnosis was not made preoperatively although it was appreciated that some marked abnormality of the ascending colon was present. Review of the films indicates that the conditions for a volvulus are present, namely, the cecum partially nonrotated and lying parallel to the transverse colon, the tip of it coming beyond the midline to the left side. No doubt an intermittent volvulus had occurred and some of the attacks of which this man complained very likely were related to that. It seems likely also that the postoperative difficulties after the gastrectomy in July, 1944, arose from a volvulus which, however, restored itself spontaneously. The final event was a complete volvulus with failure of restoration and the characteristic findings shown in the films.

CASE 3.—H. N., a white man aged 63 years, was admitted to the University Hospital March 18, 1947, with a history of acute stabbing pain in the abdomen beginning about three days earlier with the focal point about 4 cm. lateral to the umbilicus on the right side. The pain had continued with only brief remissions for three days until admission. The vomiting began on the evening of March 15 and continued intermittently at frequent intervals since. The last normal bowel movement was on March 14 but small bowel movements had occurred on

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†By Dr. R. L. Varco.

March 15 and 17 with little flatus. The past history was of little significance. On physical examination the abdomen was found to be distended but was not extremely so. There was rebound tenderness over the entire abdomen. He was tympanitic, there were no bowel sounds and no other evidences of abnormality. Roentgenogram of the abdomen (Fig. 7) was made. This revealed a marked distention of many loops of small bowel with gas but an extraordinary dilatation of the cecum which extended up under the liver and right up to the midline of the spine. The character of the distention of the cecum together with that of the

Fig. 7.

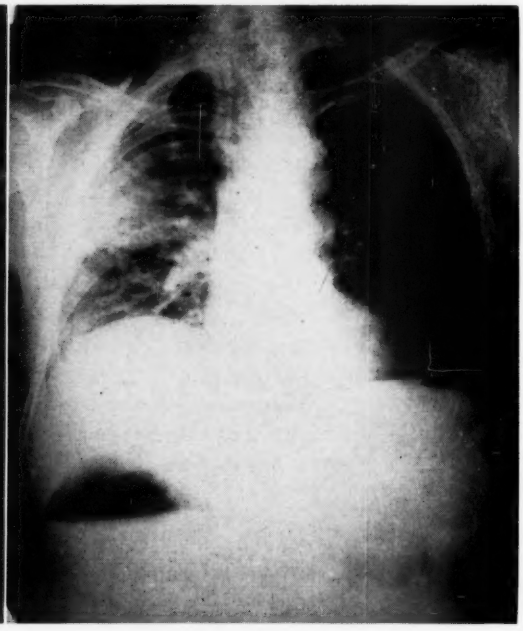

Fig. 8.

Fig. 7 (Case 3).—Roentgenogram of the abdomen three days following the onset of an acute process in the right upper quadrant. Note the tremendously distended loops of small bowel which are present largely on the left side and well distributed throughout the abdomen. In addition the cecum can be made out as an enormously dilated viscus lying in the right upper quadrant well under the liver in a very abnormal position. The exact point of obstruction is not clearly made out.

Fig. 8 (Case 3).—Upright view of the chest and abdomen shows an extensive pathologic process in the right lung of long standing. The right diaphragm is elevated. Below the liver can be made out the greatly distended cecum or ascending colon with a single fluid level. From these two roentgenograms (Figs. 7 and 8) the diagnosis was made.

small bowel and the absence of distention of the remainder of the colon led to the diagnosis of probable volvulus of the cecum. A roentgenogram of the chest was made (Fig. 8). Marked changes in the right lung were present, possibly due to an old tuberculosis. The right diaphragm was elevated. Beneath the liver could be made out a hollow viscus with a fluid level suggesting a tremendously dilated cecum containing a large quantity of fluid. This served to confirm the previous diagnosis. There was a small gas bubble under the left diaphragm and it could not be determined from this one examination whether that represented free gas from a perforation or simply a small amount of gas in the colon. A preoperative diagnosis of probable volvulus of the cecum was made. Immediate surgery was undertaken* and the volvulus involving the junction of the cecum with the ascending colon was found. Detorsion was accomplished but the changes in the bowel made it necessary to resect the cecum and ascending colon. Aseptic end-to-end anastomosis of the ileum to the transverse colon was accomplished. The postoperative course was uneventful and the patient was discharged March 30 apparently well.

*By Dr. I. D. Baronofsky.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 9 (Case 4).—Simple roentgenogram of the abdomen made a few days after the onset of symptoms of intestinal obstruction. Note the enormously distended cecum, low in the abdomen and well to the left of the midline. There is some distention of the colon as well. Because of the low position of the distended viscus this was at first thought to be a volvulus of the sigmoid, but later the diagnosis of volvulus of the cecum was made. Note the point of obstruction between the ascending colon and the hepatic flexure.

Fig. 10 (Case 4).—Same case, barium enema examination made twenty-four hours later. Distention of the cecum is still shown but the position is much less abnormal. Note the presence of distention of the loops of small bowel still remaining. It would appear from this examination that the volvulus seen in the previous roentgenogram (Fig. 9) had been reduced. The patient's symptoms had been relieved to some degree.

Fig. 11 (Case 4).—Re-examination forty-eight hours later shows a recurrence of the volvulus with the cecum identified by the residual of barium now lying up under the liver and well beyond the midline to the left.

Fig. 12 (Case 4).—Film of the abdomen made three days later, after the patient's symptoms had been completely relieved, shows the cecum and ascending colon apparently in normal position. A spontaneous reduction of the volvulus has obviously occurred. Further study could not be undertaken because the patient left the hospital against advice.

CASE 4.—F. T., a white man, aged 52 years, was admitted to the Minneapolis General Hospital May 3, 1947, with a complaint of pain beginning in the middle of the back and radiating to the flanks, following a fall from a porch. Otherwise the history was negative. There was tenderness to palpation over the lower dorsal spines. A bilateral inguinal hernia was present but there was nothing of any further significance. On roentgen examination a compression fracture of the bodies of the tenth and twelfth thoracic vertebrae was found. The patient was put on Buck's extension for the fracture of the spine with a ten pound weight to each leg. Twenty-four hours later he began to develop abdominal distention which was naturally thought to be due to a paralytic ileus. Three days after the injury the Bradford frame had to be given up. The distention apparently responded somewhat to enemas and Prostigmine but on May 7, 1947, it again became noticeable. Suction was started with a tube in the upper jejunum but the abdomen remained distended. Roentgen examination of the abdomen was undertaken at this time (Fig. 9) and an enormous distended loop of bowel could be made out in the right lower quadrant extending well beyond the midline of the abdomen to the left side. Because of the localized character of this distention and its position the possibility of volvulus of the sigmoid was considered. There was apparently a considerable amount of gas in the distal colon and even in the transverse colon so that the diagnosis of volvulus of the cecum was not given sufficient credence. The following morning a barium enema was administered (Fig. 10) and the dilated loop of bowel was then demonstrated to be the cecum. A torsion could be made out but it appeared to be only of partial degree. It was evident from this examination that the volvulus had been reduced to a considerable extent in the interim. The patient likewise showed some relief of symptoms.

On further questioning at this time it appeared that this man had had similar symptoms on previous occasions whenever he remained in bed for a few days. He was then permitted to become ambulatory and relief of the distention was accomplished. A recurrence of symptoms was followed by another roentgen examination (Fig. 11) forty-eight hours later and the cecum could now be demonstrated overlying the hepatic flexure and extending well up under the liver. There was some residual of barium remaining so that torsion had again occurred. On May 13, however, re-examination (Fig. 12) showed an apparently normal cecum and ascending colon. The patient left the hospital against advice on May 17, 1947, the abdominal distention having been completely relieved.

*Comment.*—Although it cannot be proved completely since the patient was not operated upon, this would certainly appear to be a case of intermittent, chronic volvulus of the cecum and ascending colon which was spontaneously restored to a normal situation. The characteristic distention, the appearance and position of the right half of the colon, the history of the patient, and the marked changes which occurred under observation all tend to bear out this assumption.

The treatment of volvulus of the cecum is operative. Simple detorsion of viable bowel will correct the situation for the time being but offers no assurance against recurrence, which, since an anatomic predisposition exists, is likely to occur. Fixation of the cecum and right colon to the lateral parietal peritoneum has been suggested but is not particularly effective. If the patient's condition allows, resection of the right colon and primary aseptic ileotransverse colostomy is probably the treatment of choice. In the presence of questionable viability such a procedure is mandatory, although a Mickulicz type of exteriorization resection may be employed in critical cases. Cecostomy, which has been utilized in a number of reported instances, is followed almost uniformly by a fatal outcome. It use is mentioned only to condemn it.

## SUMMARY AND CONCLUSIONS

1. Abnormal mobility of the cecum and ascending colon is the anatomic prerequisite for volvulus of the cecum. It occurs in about 10 to 15 per cent of adults.

2. The incidence of volvulus of the right half of the colon is approximately 1 per cent of all cases of intestinal obstruction.

3. The diagnosis can be made by roentgen examination from the simple film of the abdomen alone but the addition of a barium enema may present helpful, confirmatory evidence.

4. The roentgen criteria are as follows: (1) dilated cecum lying in a very abnormal position; (2) loops of small bowel lying to the right of the distended cecum; (3) the observation of the ileocecal valve lying to the right of the distended viscus may be absolutely diagnostic; (4) a cone-shaped obstruction of the ascending colon with spiral mucosal folds demonstrated on barium enema examination is likewise diagnostic; (5) usually only a single fluid level is present in the colon when upright films are made; (6) the twisted mucosal folds may occasionally be seen in the simple film of the abdomen by contrast with the surrounding mucosa.

5. A differential diagnosis must be made from volvulus of the sigmoid, adynamic ileus, and organic obstruction of the transverse or left colon.

6. Four cases, two of the acute type of obstruction and two of the chronic or recurrent type, are presented in detail. In three of these it was possible to make the diagnosis largely on the basis of the roentgen findings.

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# SURGICAL MANAGEMENT OF THORACIC DUCT INJURIES

## An Experimental Study with Clinical Application

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TRAUMATIC chylothorax is a rare but not an uncommon condition. Trauma to the thoracic duct or its tributaries may be due either to direct or indirect violence or to operative injury.

Shackelford and Fisher[1] (1938) collected 39 cases of traumatic chylothorax from the literature and added two of their own. In an analysis of the causes of traumatic chylothorax in this group there were 17 due to crushing injuries, 8 to bullet or stab wounds, 6 to a fall from a height, 5 from a blow on the chest, 4 to being thrown against the front seat of an automobile, and 1 to hyperextension of the vertebral column. Cases due to operative trauma were not included in their study.

Loe[2] in a recent case report of a bullet injury to the cervical portion of the thoracic duct associated with chylothorax found about 62 cases of traumatic chylothorax recorded in the literature.

Operative injury to the duct with chylorrhea or chylothorax is probably of more frequent occurrence than one is lead to believe from reports in the literature. The cervical portion of the duct is most frequently injured in operation on the left side of the neck for tumor or enlarged lymph nodes. If unrecognized or not treated, chylorrhea will develop. If the pleura is opened, chylothorax may also occur. In injuries to the intrathoracic portion of the duct, chylothorax with its attendant high mortality will occur unless the injury is promptly recognized and treated.

Whitcomb and Scoville[3] (1942) reported a case in which the thoracic duct was inadvertently severed during a right sympathectomy of the Smithwick type for hypertension. The injury was promptly recognized and two silver clips were placed on either end of the divided duct. However, in spite of this their patient developed a right chylothorax with pressure and nutritional symptoms and succumbed during the intravenous transfusion of the aspirated chyle.

Other cases have been reported in which the thoracic duct was injured high in the chest during esophageal resection or other surgical procedures. Simple ligation of the duct at this level was successful.

Injury to collaterals of the thoracic duct probably occurs not infrequently during intrathoracic operative procedures. The presence of chyle is obscured by the sanguineous character of the fluid that collects or is drained from the

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pleural cavity. In a relatively short period of time the tear in the lymph channel will usually become sealed. However, in an injury to a large tributary, chylorrhea may not clear up for several days.

The symptoms in chylothorax are those due to pressure and loss of chyle. The pressure symptoms may be relieved by frequent thoracentesis. However, the loss of chyle, if allowed to persist, will result in inanition and death. This is obvious when one considers its composition. Sixty to seventy per cent of the absorbed fat is in chyle. The protein content varies from 1 to 6 Gm. per cent with an average of 3 to 4 Gm. per cent. The nonprotein nitrogen, sugar, urea, and minerals are similar in amount to those found in blood serum. However, the calcium and cholesterol content are slightly lower. The lymphocyte and eosinophile count are much higher than in the blood.

The flow of chyle is at a rate of 60 to 195 c.c. per hour and will depend on the fluid intake and diet. Thus, the loss of chyle in a twenty-four hour period may exceed 2,000 c.c.

With the loss of these constituents a marked deficiency state develops characterized by weakness, hunger, intense thirst, emaciation, apathy, and death which is due to starvation. The lymphocyte and eosinophile blood count are reduced.

Treatment of chylothorax has been medical, surgical, or combined. In the medical management a proper diet low in fats and rich in protein and vitamins is given. Blood transfusions, plasma, glucose, saline solution, intravenous infusion of aspirated chyle, and thoracentesis have been employed. These supportive measures may maintain the patient's nutritional status until spontaneous or operative repair of the injury is carried out.

In operative injuries it is paramount that the injury be recognized at the time and appropriate treatment carried out. Various methods of management have been advocated. As early as 1903 Deanesly[4] advocated implantation of the severed duct into a near-by vein. He successfully implanted the cervical thoracic duct which was severed during removal of tuberculous lymph glands into the left internal jugular vein. Harrison[5] in 1916 implanted the divided cervical thoracic duct into the left external jugular vein. He advocated this as the most physiologically sound method when suture of the duct is impossible. Ligation or packing is resorted to if the other methods cannot be successfully carried out.

In injury to the thoracic portion of the duct, unless in the upper part where there is rich collateral circulation, ligation may be followed by rupture due to the increased intraductal pressure brought about by acute obstruction. A safer method must therefore be used since the surgical mortality in traumatic chylothorax has been reported to be around 100 per cent and about 50 per cent in the over-all total cases reported (Loe[2]).

With recognition of the seriousness of this condition and the associated high mortality, experiments were carried out to study and find a rational method of surgical management.

## METHOD

A group of twelve large healthy dogs was used. All were operated upon employing endotracheal positive pressure ether anesthesia. The thoracic duct was approached through the right tenth intercostal space. After entering the thoracic cavity the mediastinal pleura was incised above the diaphragm. The duct lying over the vertebral column and posterior and slightly to the right of the aorta was easily identified. It was then dissected out to the level of the cysterni chyli. Just above the diaphragm the duct was usually found to be a large single trunk with occasional small collaterals. About 6 cm. from the diaphragm relatively large collateral lymphatic trunks were found.

In six animals a 3 cm. segment of the thoracic duct was excised just above the diaphragm. In all there was immediate chylorrhea. The mediastinal pleura was left open and the lung re-expanded. The chest incision was closed in layers with catgut and the skin was closed with silk.

In three animals the thoracic duct was ligated with silk at the level of the diaphragm and 4 to 5 cm. above. The segment of duct between the ligatures was then excised.

In another three animals a small segment of the thoracic duct at the level of the tenth thoracic vertebra was excised and the proximal thoracic duct just above the diaphragm was implanted into the azygos vein which is in close relationship. The technique will be described later.

## RESULTS

In the six dogs in which a segment of the thoracic duct was excised and the divided ends left open, four recovered and two died, one in forty-eight hours and the other in six days. Both had a massive right chylothorax and developed symptoms due to pressure and loss of chyle. Autopsy was done in two weeks in the four that recovered. Examination disclosed moderate fibrosis about the thoracic duct which was sealed and there were numerous dilated lymph channels. All four animals had evidence of lymphaticovenous anastomosis with the azygos and intercostal veins.

In the three animals in which a segment of the thoracic duct was excised and the ends ligated, recovery was uneventful. Autopsy two weeks later revealed dilated collateral lymph channels but no lymphaticovenous anastomoses. There was slight fibrosis about the divided ends of the duct.

Two of the three animals in which a segment of the thoracic duct was excised and the proximal stump implanted into the azygos vein made an uneventful recovery. An autopsy two weeks later disclosed patency of the communication.

The third animal died on the sixth postoperative day and at autopsy an empyema and bilateral pneumonia were found. The anastomosis between the thoracic duct and azygos vein was patent.

## DISCUSSION

It is interesting that in the first group of dogs in which a segment of the thoracic duct was excised recovery occurred in two-thirds. Closure of the

open ends of the duct and collateral channels and lymphaticovenous anastomoses developed. Smith and Woliver[6] reported a case of traumatic chylothorax following resection of the entire tenth rib and associated muscles for Ewing's sarcoma of the rib. At operation chyle was noted near the vertebral border but the thoracic duct was not visualized. Pressure symptoms developed on the third postoperative day and on the fifth day thoracentesis was carried out with aspiration of 900 c.c. of chyle. In the following twelve days 7,800 c.c. of

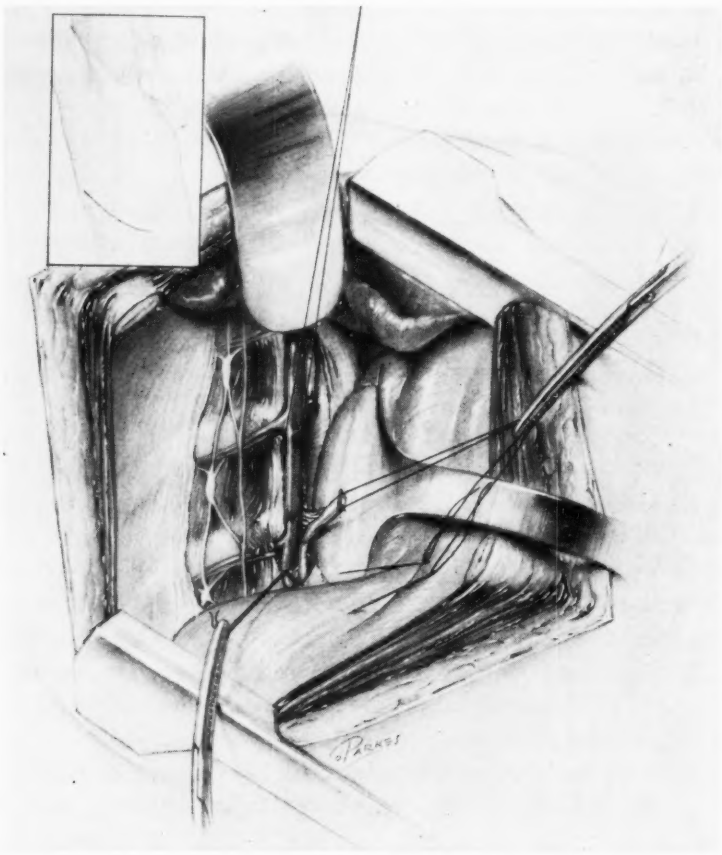

Fig. 1.—The divided thoracic duct being prepared for implantation into the azygos vein which is in close proximity.

chyle were removed in five thoracenteses. On the fourteenth day there was no further accumulation of chyle. In this case healing occurred. However, it is quite possible that a large tributary of the thoracic duct or a part of the wall was injured without complete severance of the main duct.

Simple ligation of the thoracic duct at any level in the dog is usually followed by no untoward effects. Blalock and associates[7] and Lee[8] have shown that it is extremely difficult to obtain complete lymphatic blockage in experimental animals. In man ligation of the duct in the cervical and upper thoracic portion has been successful. However, in ligation of the lower third where the

collateral circulation is not as rich as in the upper, rupture may occur from a high intraductal pressure brought on by the acute obstruction.

It appears that in injuries of the lower part of the thoracic duct ligation is unsafe. If a primary repair of the injured or severed duct cannot be accomplished, then implantation of the thoracic duct into the azygos or other suitable vein should be carried out. This treatment appears to be the most physiologic if primary repair cannot be accomplished. We have successfully carried out such a procedure in a patient in whom the thoracic duct was inadvertently severed during the course of a transthoracic thoracolumbar sympathetectomy for hypertension. The case will be presented in more detail.

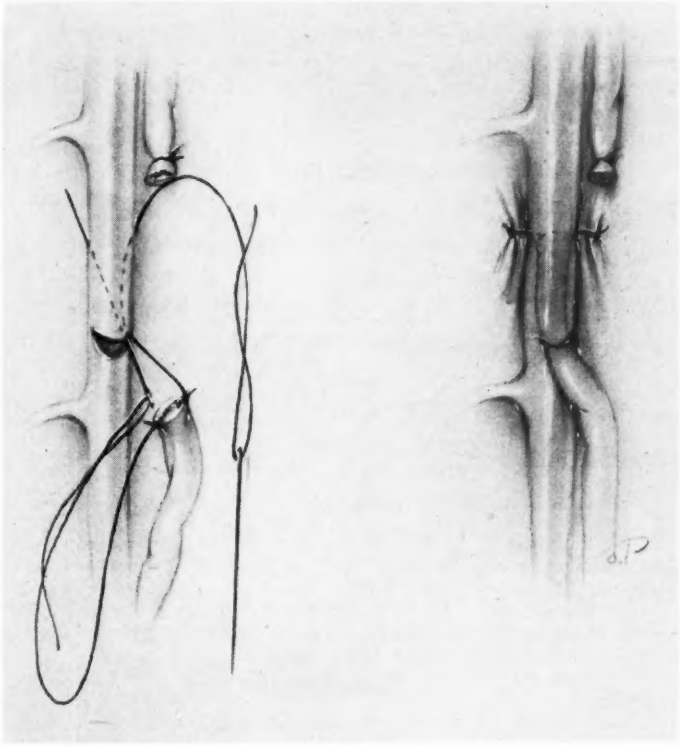

Fig. 2.—Technique of implantation of thoracic duct into the azygos vein.

## CASE REPORT

L. D. (B84652), a 49-year-old white married woman, was admitted to Duke Hospital on July 24, 1946, with a chief complaint of high blood pressure of fifteen years' duration. She had done well until three years previous to hospitalization when the headaches became more severe and she began having vertigo, blurring of vision, and scotomas. The blood pressure was 210/125.

After complete examination sympathetectomy was recommended. On Aug. 15, 1946, a left transthoracic thoracolumbar sympathetectomy, splanchnicectomy, and celiac ganglionectomy were carried out. The postoperative course was uneventful. On Aug. 29, 1946, the second stage was carried out on the right side. The tenth rib was resected and the thoracic cavity entered. After the lung was retracted the mediastinal pleura was incised along the course of the sympathetic chain which was resected from the fifth thoracic to the second lumbar ganglia.

In dissecting the major splanchnic nerve the thoracic duct was inadvertently torn with the prompt escape of chyle. The sympathetectomy was completed. It was impossible to reconstruct the severed thoracic duct by primary anastomosis. The alternatives were to ligate the duct, to transplant it into the soft parts posteriorly, or to implant the duct into a vein. The latter seemed more desirable and the azygos vein was selected.

Fine black silk sutures were then placed on either side of the thoracic duct using a straight intestinal needle (Fig. 1). The azygos vein was then ligated close to the diaphragm. The intercostal vein just above was doubly ligated and divided. A traction suture was placed around the azygos vein just below the entrance of the next intercostal vein to prevent bleeding. An opening was then made into the vein about the size of the diameter of the thoracic duct. The intestinal needles were then passed up the vein and out on either side and the duct was pulled into the vein for a distance of about ¾ cm. The sutures were then anchored to the surrounding tissues (Fig. 2). The chest was closed in layers. A pezzer catheter was placed in the ninth interspace in the posterior axillary line for drainage.

The postoperative course was smooth and uneventful. At no time did the patient show evidence of chylothorax or nutritional disturbances. During the first week the fat content of the diet was restricted. She was discharged from the hospital on the fourteenth postoperative day with a blood pressure of 136/78.

## SUMMARY AND CONCLUSIONS

The problem of traumatic chylothorax has been reviewed.

Experiments have been reported in which successful transplantation of the thoracic duct into the azygos vein has been accomplished.

The clinical application of this method has been carried out in a case of operative injury to the thoracic duct. This method is not only applicable to those cases of traumatic chylothorax but may be of value in chylothorax due to obstruction from various causes (tumor, inflammation, thrombosis of subclavian vein, etc.) in the upper mediastinum.

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# THE EFFECT OF CARONAMIDE* WITH HEPARIN† ON THE COAGULATION OF HUMAN BLOOD

## A Preliminary Report

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MANY papers[1-5] have appeared in the literature concerning the favorable results obtained from the use of Caronamide to prolong and augment the blood level of penicillin. Caronamide (4′-carboxyphenylmethanesulfonanilide), when given orally, inhibits the tubular excretion of penicillin as well as para-aminobenzoic acid, Diodrast, and other compounds totally unrelated structurally to Caronamide.[2, 6] Heparin levels, like penicillin levels, are hard to sustain. In this institution, work on heparin and the thrombosis problem has been in progress, and it occurred to us that Caronamide might have a similar effect for heparin as for penicillin, thereby making it more effective and less expensive to administer.

Beyer[7, 8] has postulated that the method of action of Caronamide in prolonging penicillin levels is one of competition with penicillin for the enzyme transport mechanism by which penicillin is excreted through the renal tubules. Caronamide itself is largely filtered by the glomeruli.[1, 9] Howell,[10] Wilander,[11, 12] and Copley and Schnedorf[13] have shown in animals that 9 to 40 per cent of intravenous heparin can be recovered in the urine in the first hour. Although the renal excretory mechanism for penicillin and heparin might not be the same, no satisfactory inference could be made without a clinical test. Previous workers[1, 2, 6, 14] have shown that there are no significant toxic effects even after prolonged administration of large doses of Caronamide, as evidenced by the clinical behavior of the patient and liver and kidney function tests.

### METHODS

Ten patients were picked at random from the surgical service at the University Hospital. These individuals were in the preoperative phase and suffered from various illnesses, none of which contraindicated the administration of heparin.

The effect of Caronamide-heparin was determined by performing heparin tolerance tests on successive days before and after the administration of Caronamide. Each tolerance test was performed by obtaining a base-line coagulation time and then injecting 25 or 50 mg. of heparin intravenously. Coagulation times were determined for the 20- 40- 60- and 90-minute periods following the injection. A 1 c.c. blood sample is placed in each of three clean, dry, 12 by 75

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*Caronamide (Staticin) used in these experiments was supplied by Sharp & Dohme, Inc., Glenolden, Pa.

†Heparin in saline was supplied by The Upjohn Company, Kalamazoo, Mich.

mm. glass tubes. In heparinized blood, the red cells and plasma separate to form two distinct layers, and the end point is read at the moment of coagulation of the red cells.[15]

On the first day of the experiment, the heparin tolerance test alone was performed. On the second day, the heparin tolerance test was repeated one-half hour after Caronamide was administered in either of two ways: (1) 2 Gm. orally every three hours for six doses; or (2) a single 4 Gm. dose. The peak of Caronamide blood level occurs approximately one-half hour after an oral dose.[16] No more Caronamide was given at any time during the experiment. The 25 or 50 mg. tolerance test (as the case may be) was then repeated once daily until the coagulation curves returned to normal.

Protamine sulfate titrations[17] of heparin levels were performed simultaneously with the coagulation times on the last seven patients. Prothrombin determinations were made on alternate days.

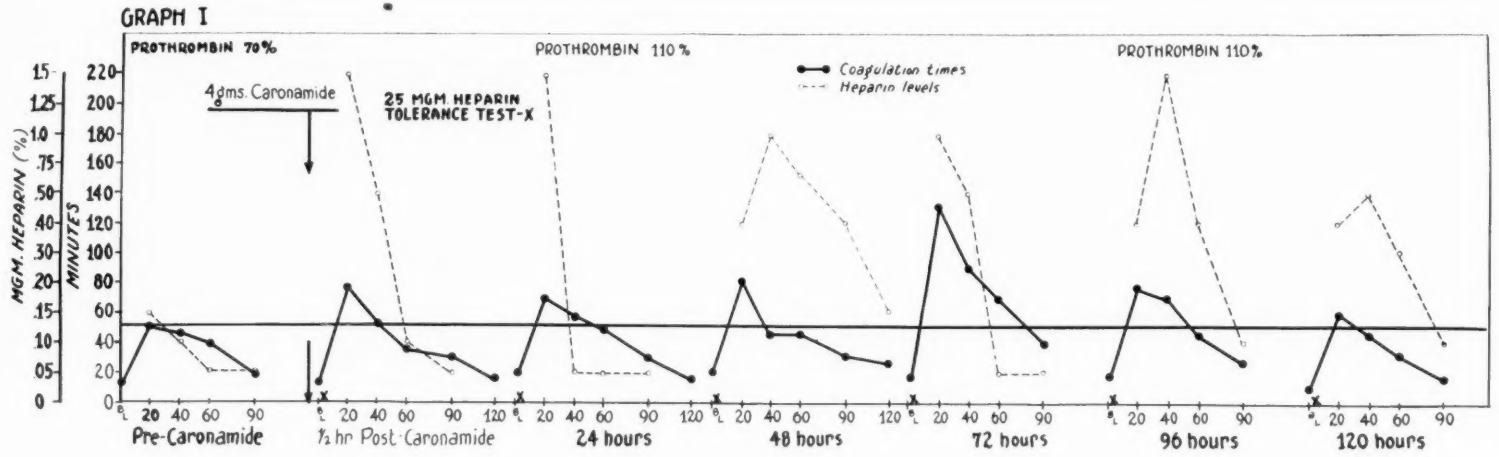
## RESULTS

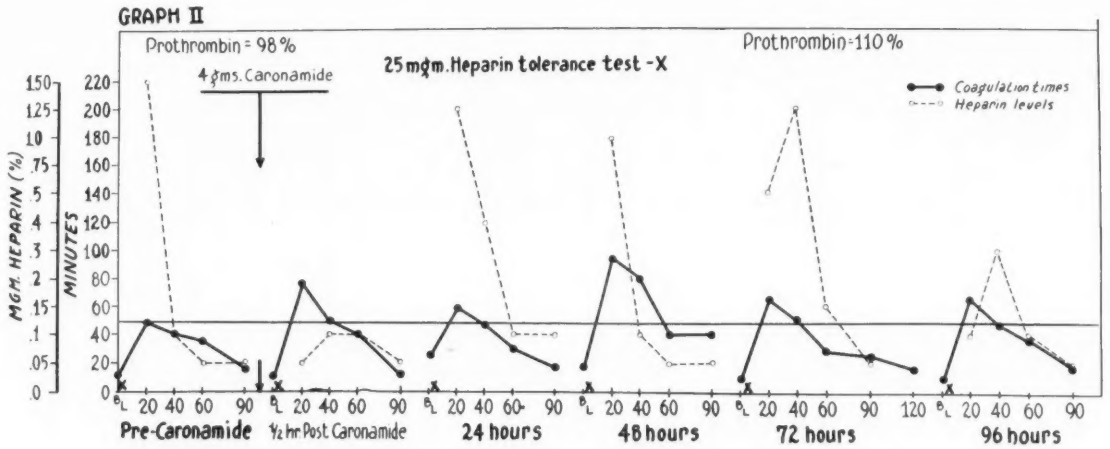
*Maximum Response* (five patients).—Graph I illustrates the results obtained from one patient of this group. In all patients in this category, the coagulation time of the 20-minute sample of the peak day was prolonged three to ten times that of the corresponding sample of the pre-Caronamide control. It should be noted that the blood sample drawn at "20 minutes" always has the longest coagulation time; the times of that sample become gradually more prolonged on successive days until a peak is reached 72 hours after the last dose of Caronamide. This is followed by a gradual decline of the peaks to normal. In three patients of this group, the coagulation times of the 20-minute sample were six to ten times more prolonged at the peak period than those of the respective point on their control curves. This patient represents the smallest response of this group.

*Intermediate Response* (three patients).—Graph II illustrates the results obtained from one of these three patients. The coagulation time of the 20-minute peak period sample, as compared to the control curve, was only doubled. The fact that in this patient the peak was at 48 instead of 72 hours may be of no significance.

*Minimal Response* (two patients).—Graph III. Even though the coagulation time of the 20-minute sample of the peak period (which occurred 120 hours after the last dose of Caronamide) reached 2 hours, it was only 30 minutes longer than the pre-Caronamide control curve. However, it will be noted that the 40-minute sample is almost twice the respective pre-Caronamide coagulation time. This individual is apparently a hyper-reactor to heparin[18] and, therefore, is not strictly comparable to the other individuals.

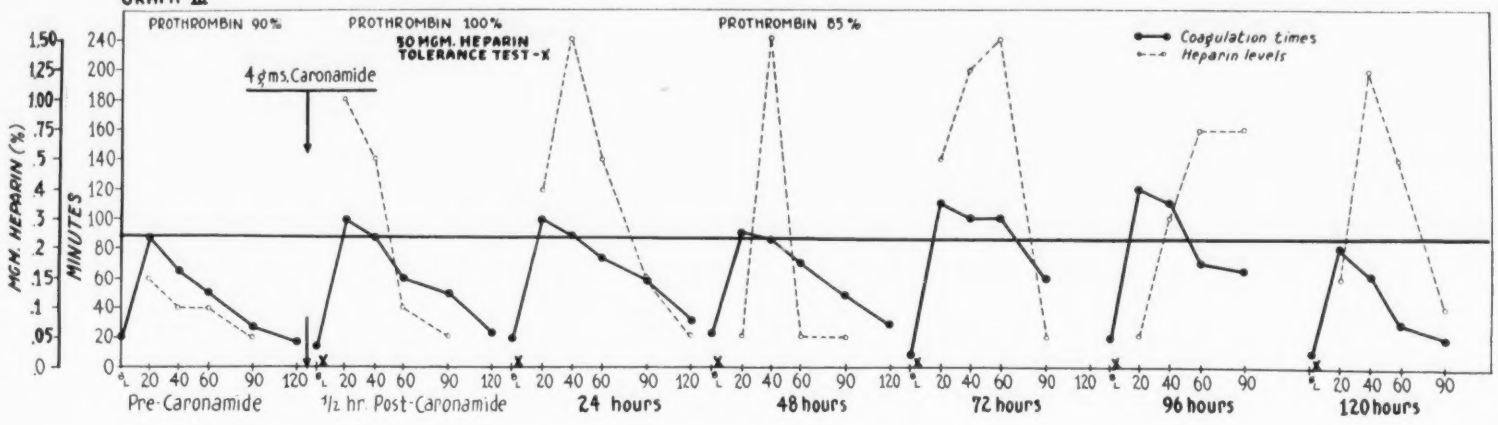
*Group Averages* (all ten patients).—Graph IV is a composite graph of the averages of the coagulation times of all ten patients for each period. The curve clearly demonstrates the predominance of the 72-hour peak, the gradual rise in the coagulation time in the first 48 hours, and the more rapid decline to pre-Caronamide response 120 hours later. At the peak period, coagulation times are approximately three times longer than the pre-Caronamide levels in all except



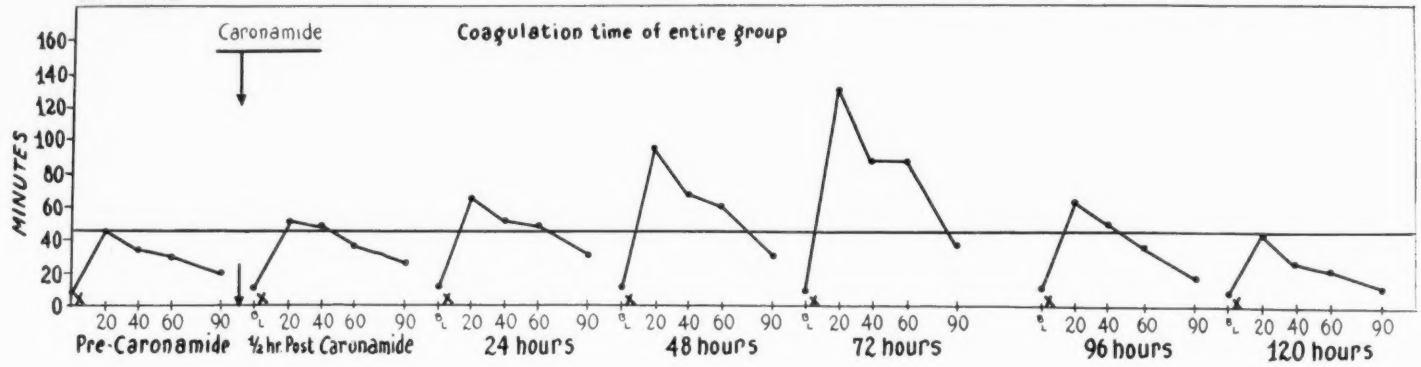




Graphs I to IV courtesy Ohio State University Department of Photography.

GRAPH III




GRAPH IV



the 90-minute sample. The coagulation times of the 48-hour period are twice those of the base-line levels; those of the 24- and 96-hour periods are just slightly less than double.

*Heparin Levels.*—In reviewing all the graphs, the heparin levels were noted to show no typical pattern, either by comparison of the curves of the same patient on successive days of the experiment, or by comparison of all the patients' curves for any one particular period. Some of the levels were highest at the 20-minute drawing; others peaked at 40 minutes. Some curves fell abruptly to normal after the peak; others declined gradually. The averages of the heparin levels of all ten patients were plotted in a curve similar to the one in Graph IV. It was not considered significant because of its lack of correlation to any individual case.

It would seem that these small doses of heparin produced a maximum effect within a few minutes after injection and then were rapidly eliminated in the course of one hour (see Graphs I, II, and III). There appears to be another factor, other than the titer of heparin itself, in producing such an enhancement of the coagulation time. In each of several patients, at the same period that the coagulation time was increased six to ten times those of the control time, the heparin levels of both periods remained comparable.

*Prothrombin Determinations.*—At the beginning of the experiment, and on alternate days thereafter, prothrombin determinations were performed from blood samples drawn prior to the injection of heparin for that day. The per cent of prothrombin determined before the experiment was within normal limits in all patients. In no case were they depressed significantly after Caronamide-heparin administration. On the contrary, in four patients the per cent of prothrombin actually rose during the experiment. This response is perhaps not the result of an increase in prothrombin, but rather, of some fundamental alteration in the clotting mechanism.

*Concerning the Time Relationship of the Administration of the Two Drugs.*—A group of three patients was given 2 Gm. of Caronamide every 3 hours for 6 doses, the last dose to be followed in one-half hour by a tolerance test of 25 mg. of heparin. When these individuals failed to have the same response as the others, investigation revealed that 2 to 3 hours had elapsed between the last dose of Caronamide and the intravenous heparin. Four days later, the same patients were given a single 4 Gm. dose of Caronamide, and one-half hour later, 25 mg. of intravenous heparin. This time they responded in the same fashion as the previous cases. This incident suggests that the single dose (or the last of multiple doses) of Caronamide is the important one and that the heparin must be given at the proper interval following it in order to initiate the process.

## DISCUSSION AND CONCLUSION

It has been demonstrated in the foregoing data that Caronamide administered as a single 4 Gm. dose, or as a course of multiple doses, markedly increases the effect of heparin on the coagulation time of human blood. Of ten patients, eight had a response resulting in a prolongation of the coagulation time (reaching a peak response approximately 72 hours after the administration of Caron-

amide) of two to ten times greater than pre-Caronamide levels. This increase in coagulation time is present to a lesser extent at the 40- and 60-minute drawings. In a few instances, a marked increase in the total length of heparin effect occurred.

Previous mention has been made of the two different methods of administering Caronamide, and the results have demonstrated that there is no appreciable difference when either method is employed. However, we believe that it is most important to give the last of multiple doses of Caronamide (or the single dose) one-half hour prior to the administration of the heparin. Evidently, in order to obtain a maximum result from Caronamide-heparin, the optimum blood concentration of each must be present simultaneously.

Unpublished data concerning urinary excretions of heparin made during the course of these experiments, the implication of the rapid fall of the heparin blood levels, and the progressive daily enhancement of the heparin effect suggest that the results are not solely due to altered renal tubular function. For this reason, two theories have been postulated to explain this phenomenon: one of us (H.D.S.) feels that a new compound is formed which exerts a reversible inhibitory effect on the site of production of the "anti-heparin" in the body. Charles and associates[19] have isolated a substance with an "anti-heparin" property during one of the stages of preparation of heparin from lung tissue. If the new compound acted upon the circulating "anti-heparin" itself rather than the site of its production, then one might expect the response on the first day to be higher than those of the succeeding days. The pattern of the curves on Graphs I to IV demonstrates the converse—the least response on the first day with a progressive rise of the curve on successive days. With each successive dose of heparin, the already present circulating "anti-heparin" is consumed, so that by the third day, for example, the titer of "anti-heparin" is least. Finally, when the titer of "anti-heparin" is lowest, the injected heparin is relatively unopposed and produces the longest coagulation time. The return to normal on the days following the peak period would be a manifestation of the gradual recovery of the mechanism which produces the "anti-heparin." This progressive daily increase in coagulation time response to heparin is somewhat analogous to the delayed action of dicumarol in depressing prothrombin level.

The other theory (R. S. M.) also postulates that a new chemical compound is formed. This is suggested by the necessity for the close correlation of blood level peaks of Caronamide and heparin to establish the gradually increasing enhancement of heparin activity. The fact that the maximum response is obtained after approximately 72 hours indicates the possibility that the compound thus formed may increase quantitatively by autoreproduction. Nucleoproteins are known to have such propensity and result from a union of protein and nucleic acid. Nucleic acids are polymers of nucleotides, themselves formed from phosphoric acid, a pentose sugar, and a purine or pyrimidine ring. Caronamide contains 2 benzene rings, and the work of Beyer and co-workers[14] has disclosed that a pentose sugar appears not infrequently in urine during the administration of Caronamide and suggests it may be a metabolic product of Caronamide itself. Although the strong negative charge of heparin, from the sulfate ions present,

makes the formation of a nucleic-acidlike compound less probable than if phosphate ions were present, it is considered chemically possible for such a compound to be formed. Earle and Brodie[9] have shown in dogs that 59 to 68 per cent of Caronamide is bound on plasma proteins. In addition, with the known proclivity of heparin to form complexes with plasma proteins,[20, 21] a compound not unlike a nucleoprotein in characteristics or capability may be formed when plasma proteins, heparin, and Caronamide are united in vivo. If such a compound were formed, and increased in quantity, it could call forth its own antagonist and thereby be gradually decreased in activity, or excreted in the urine. Such a compound would then act either synergistically with newly injected heparin in such a manner as to increase its anticoagulant effect, or antagonistically to a physiologic "anti-heparin." This theory is also partially suggested by the fact that the base-line coagulation times and prothrombin times do not increase, and, therefore, such a compound appears not to have a measurable effect on the physiologic balance maintaining normal coagulability. Experiments are under way to attest or disprove these theories.

At present, the cost of heparin and the difficulty in maintaining an adequate prolongation of the coagulation time detracts considerably from its usefulness in the treatment of thrombosis. Heparin in Pitkin's menstruum has provided a better means for administering a therapeutic course, but this method still has some undesirable features. It is hoped that the studies[22] of Caronamide with heparin in Pitkin's menstruum, now in progress, may provide a better solution to the problem of heparin therapy. The fact that the results described in this paper can be achieved with such small doses of heparin makes the outlook appear promising for reducing the cost of heparin therapy. Further studies with oral and intravenous Caronamide in combination with aqueous heparin and heparin in saline solution administered by various routes are also in progress.

## SUMMARY

1. Intravenous heparin in saline solution, given one-half hour after a single dose of Caronamide, causes a progressive enhancement of the effect of an equal dose of heparin administered on each successive day.

2. In eight of ten patients, this enhancement reached a peak in approximately 3 days and is manifested by a two- to tenfold increase in coagulation time response to heparin.

3. This peak is followed by a gradual return to a normal response, 2 to 3 days later.

4. Incomplete evidence suggests that this effect may be due to the formation of a new compound and not to Caronamide blockage of the renal excretion of heparin.

5. The fact that the results described in this paper can be achieved with such small doses of heparin make the outlook appear promising for reducing the cost of heparin therapy.

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# ANEMIA FOLLOWING RESECTION OF INTESTINE

## Clinical and Experimental Observations

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ANEMIA following gastrectomy and resection of the intestine may become a serious problem. Interest was stimulated in the latter recently by two patients with marked anemia following resection of the intestine. Many varieties of anemia may occur following surgery. The most common form, normochromic normocytic, occurs immediately after operation and is due to blood loss. The next most frequent type develops as a result of nutritional disturbances, inadequate iron absorption, and vitamin deficiencies. This is also described as secondary or hypochromic anemia, and responds to the administration of adequate amounts of iron, vitamins, food, and the removal of infection. The macrocytic anemias are seen as a result of deficient production or absorption of the erythrocyte maturing factor, and derangements of the gastrointestinal tract. The clinical manifestations are those of sprue or pernicious anemia and present as a macrocytic hyperchromic form.

Two patients who developed anemia following extensive resection of the intestines are discussed. The results of preliminary experimental work on dogs in an attempt to reproduce this condition are also included. A review of previous work has been made in an effort to determine the relationship between the hyperchromic macrocytic anemia and the lesions in the gastrointestinal tract. Previous writers have reported macrocytic anemia with terminal ileitis, linitis plastica, total gastrectomy, fish-tape worm infestations, strictures, anastomoses of the intestines, and resection of the small intestine.

### CASE REPORTS

H. C., a white girl, aged 19 years, was admitted to Emory University Hospital on Oct. 29, 1946, with complaint of severe abdominal pain, diarrhea, and pain on defecation. The patient had been subjected to exploratory laparotomy at the age of 6 years for intestinal obstruction due to volvulus. This was corrected by rotation of intestinal loops. The patient remained well for two years but later developed an acute intestinal obstruction for which operation was performed. A recurrent volvulus was found at the site of a Meckel's diverticulum. In addition, there was an absence of fixation of the mesentery to the posterior abdominal wall. It was necessary to resect approximately six feet of the terminal ileum, with end-to-end anastomosis. A third operation was performed approximately one month later for a recurrent obstruction from postoperative adhesions.

Upon completion of this surgery, the patient remained in good health until two years before the last admission, at which time she began to have diarrhea, abdominal cramps, and signs of anemia. Multiple transfusions, sulfonamides, vitamins, liver, and iron were administered, and she improved temporarily and returned to work.

Three months prior to admission, the abdominal cramps became more severe and the diarrhea more intense, with as many as fifteen to twenty stools a day. Marked ulceration of the rectum and sigmoid colon occurred with extensive fissures in and around the anus. Findings from stool cultures were negative. Barium enema showed evidence of an incom-

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plete intestinal obstruction. Gastric analysis revealed a marked decrease in total acidity, with an absence of free acid. The patient was given many opiates for the relief of this discomfort, and when admitted to the hospital she was taking codeine and morphine frequently. On admission to the hospital the patient showed marked anemia: 2,300,000 red blood cells, 6.5 hemoglobin, 4,100 white cells, and a normal differential count. She was given three transfusions within a week with no appreciable change in the hemogram. She was then given 25 mg. folic acid daily, and immediate response occurred. In one month the erythrocyte count rose to 4,500,000 and the hemoglobin to 12.6 Gm. The diarrhea and pain on defecation disappeared, and the patient gained weight.

TABLE I. LABORATORY FINDINGS (H. C.) BEFORE AND AFTER TREATMENT WITH FOLIC ACID

| DATE | R.B.C. (M.) | W.B.C. | Hb. (GM.) | PLATELETS (CU.MM.) | RETICULOCYTES (PER CENT) | THERAPY |
|---|---|---|---|---|---|---|
| | | | | | | BEFORE ADMISSION |
| | | | | | | 6 transfusions past month |
| 10/29/46 | 2.3 | 5,100 | 7.1 | | Less than 0.1 | |
| 11/ 8/46 | 2.7 | 2,750 | 8.45 | | | AFTER ADMISSION |
| | | | | | | 3 transfusions |
| | | | | | | Iron and vitamins |
| 11/11/46 | 3.0 | | | 240,000 | | Folic acid only |
| | | | | | | 25 mg. daily |
| 14 | 3.04 | 4,300 | 8.9 | | 25.0 | |
| 18 | 3.6 | 9,200 | 10.5 | 400,000 | 14.0 | |
| 22 | 4.13 | 6,400 | 11.6 | 300,000 | 10.0 | |
| 26 | 4.39 | 18,350 | 13.6 | 439,000 | 2.9 | |
| 12/ 2/46 | 4.06 | 5,450 | 12.6 | | 7.0 | |
| 6 | 4.5 | 4,750 | 12.6 | 249,000 | 1.5 | |

Mrs. F. J., aged 55 years, was diagnosed as having carcinoma of the cecum and ascending colon in 1937. At that time she had a blood count of 1,900,000 with marked hypochromic anemia. A one-stage ileotransverse colostomy was performed with resection of the cecum, ascending colon, and a portion of the terminal ileum. The patient did well postoperatively, except for persistent anemia. She showed no evidence of recurrence of the carcinoma for this ten-year period. She was given large quantities of iron and liver with only slight improvement. This improvement, however, was temporary, and the anemia returned as soon as treatment was discontinued. At no time did the anemia disappear completely. The administration of folic acid was begun in March, 1947, concurrently with iron and liver, and a marked rise in the erythrocyte count and hemoglobin resulted. At the present time there is some evidence of hyperchromia. The red count is approximately 4,000,000 and the hemoglobin 10 Gm.

In 1890, White[1] described a series of thirty-one cases of pernicious anemia in which six patients, at autopsy, had macroscopic lesions of the gastrointestinal tract. In two of these there were cicatricial changes in the ileum. Faber,[2] in 1895, described a case of pernicious anemia in a young woman, with fibrous thickening in the wall of the distal part of the jejunum and stricture formation demonstrated at autopsy. He suggested at this time that the anemia resulted from the absorption of a toxin from the stagnant bowel contents.

Meulengracht,[3] in 1921, observed at autopsy a tuberculous stricture of the ileum in a case of severe pernicious anemia, and also found that the entire small intestine was heavily infected with bacteria. On reviewing this case and similar ones, he concluded that (1) pernicious anemia may develop on the basis of benign intestinal strictures; (2) the anemia was probably due to the absorption

of hematoxic substances from the dilated and infected portion of the bowel above the strictures; (3) such cases support the theory of the intestinal origin of cryptogenetic pernicious anemia.

The work of Castle and his group,[4, 5, 6, 7] in 1929 to 1930, has done much to clarify the etiologic basis for pernicious anemia and other similar macrocytic anemias. In order to understand the gastrointestinal relationship, it is necessary to review the process by which red blood cells are developed and released to the peripheral blood. An unidentified substance, the "extrinsic" factor, is ingested in the diet, and this reacts with an "intrinsic" factor, probably an enzyme, which is contained in the gastric secretions. The substance which forms as a product of this interaction controls the rate of formation of red blood cells in the bone marrow. Thus, since red cells are not normally released until maturity, a disturbance anywhere in this process will result in a diminution of the number of red cells released to the peripheral circulation, and anemia will then develop.

Goldhamer[8, 9] has shown that pernicious anemia is due to a diminution of the intrinsic factor. Sturgis and Goldhamer[10] believed that the anemia in stricture and anastomosis of the intestine may be due to a failure to absorb the substance which results from the interaction between the extrinsic and intrinsic factors. Kracke,[11] however, has shown that this substance may be stored, synthesized, and released in the kidney and in other tissues.

Ryti[12] in 1927, Glatzel[13] in 1929, and Sturgis and Goldhamer[10] in 1939 each reported a case of hyperchromic macrocytic anemia following resection of small intestine. In each of these cases, after four, five, and five years, respectively, the patients developed a hyperchromic or macrocytic anemia, and a hypochylia or an achylia. Other reports of extensive resections of the small intestine have been made but contain no conclusive information regarding the blood picture.

Terminal ileitis is also rather frequently accompanied by a hyperchromic macrocytic anemia. Plum and Warburg[14] have reported four patients in whom this condition occurred, three of whom had a hyperchromic anemia. They found a much lower incidence of hyperchromic anemia in a series collected from the literature. Butt and Watkins[15] reported upon seven patients with ileitis, six of whom had a macrocytic anemia. None of these patients were benefited by liver therapy, but there was recovery with operation. In the series of Plum and Warburg, two of the three patients developed a normal blood picture after liver therapy. They considered the anemia on a deficiency basis.

Barker and Hummel,[16] studying macrocytic anemia in association with intestinal strictures and anastomoses, collected forty-nine cases from the literature, to which they added two of their own. They found macrocytosis in forty-eight of forty-nine, and hyperchromia in thirty-two of forty-two. They considered the two most plausible explanations for the development of this anemia to be (1) failure of formation of the hemopoietic principle or destruction of the principle in the gastrointestinal tract through abnormal bacterial activity; and (2) the absorption of toxic products of bacterial putrefaction in amounts too great to be neutralized by the normal detoxifying mechanisms of the body. They believed that instead of regarding the active principle of the liver as being an

erythropoietic substance, it may be necessary to promote detoxification of some chemical compound or compounds, which if unneutralized might lead to a variety of harmful changes throughout the body. The macrocytic anemia resulting from strictures would thus be an intestinal toxemia, which could be alleviated by removing the cause of the stagnation and putrefaction of the intestinal contents, or by administering excessive amounts of the liver principle in order to detoxify the excess of toxins absorbed.

In 1941, Petri, Norgaard, and Jensenius[17] reported a series of experiments in which they attempted to produce a condition simulating pernicious anemia in dogs. Sharpe, McKean, and Heide,[18] and Meulengracht had previously reported the degrees of effectiveness of different parts of the stomach and duodenum of swine in the treatment of pernicious anemia. Thus, Petri and his group performed resections of the stomach and duodenum in varying combinations in an effort to eliminate the intrinsic factor. These procedures constantly resulted in the production of a chronic subpellagra or an acute or chronic pellagra, but only two of twenty-five animals developed a hyperchromia.

Petri and his group[19] then extended their combined resections to include also the distal two-thirds of the small intestine. In doing this they attempted not only to eliminate an assumed site of formation of the intrinsic factor, but in addition they believed that they would remove an essential portion of the area in which presumably the interaction between the intrinsic and extrinsic factors is referred. This might, in addition, eliminate the site of absorption of the active principle. All of the animals developed an achylia, and two of three developed a hyperchromic macrocytic anemia. All developed skin and central nervous system changes, but the bone marrow was hypoplastic, rather than of the hyperplastic type seen in pernicious anemia. The condition thus resembled sprue, terminal ileitis, tropical macrocytic anemia, idiopathic steatorrhea, and fish-tapeworm infestation.

Petri and his group[20] then attempted to find exactly what part the resection of the distal small intestine had played in the production of the pathologic picture observed in the combined resections. They resected the distal 81 per cent, 60 per cent, and 63 per cent of the small intestine of three pups. In each of these a hyperchromic, macrocytic anemia developed, beginning between seventy-five and ninety-one days postoperatively. They concluded from these experiments that isolated resection of the small intestine produced fundamentally the same type of endogenous pellagra as did resection of the pylorus and Brunner gland area of duodenum and distal two-thirds of the small intestine, and as resection of the pylorus and Brunner gland area of the duodenum. The hyperchromic macrocytic anemia, hypoplasia of the marrow, and diarrhea constitute a specific enterogenous phenomena, in that they were not seen after resection of the pylorus and Brunner gland area of the duodenum alone. Yet they appeared of the same nature or even accentuated by isolated resection of the small intestine.

Viewing the results of these experiments in the light of clinical observations, it would seem that this type of anemia is due to faulty or absent absorption or

production of substances that ordinarily counteract macrocytosis and hyperchromia, namely, antipernicious anemia factor and vitamin B. Or, according to Petri, they may be attributed to a possible toxic effect on the liver and bone marrow that is related to the chronic state of diarrhea which is present in this condition.

In an attempt to produce a hyperchronic macrocytic anemia in experimental animals, massive resections of the small intestine were performed in adult dogs. This was done to determine if the same results obtained by Petri in puppies could be produced in older animals, and to enlarge the number of animals in which a surgical anemia had been produced. It was also believed that these animals would lend themselves well to the study of various therapeutic methods, particularly folic acid.

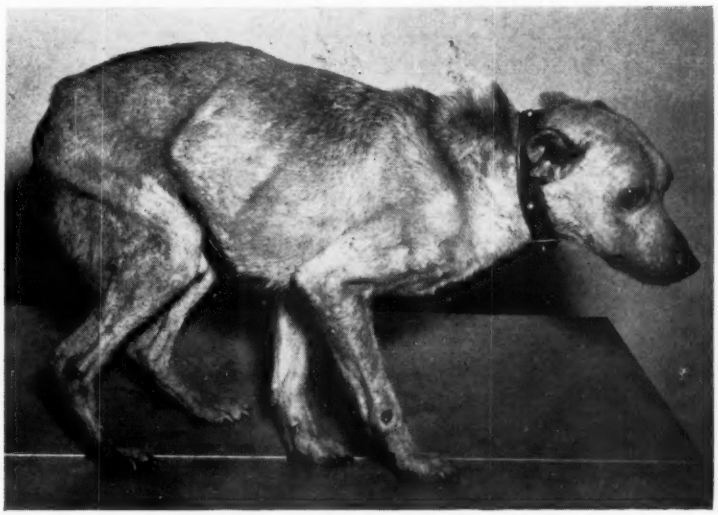

Fig. 1.—Photograph of dog showing extreme malnutrition and ulcerations on extremities following massive resection of the small intestine.

## EXPERIMENTAL PROCEDURE

Adult dogs were used, the weights averaging 9 to 15 kilograms. After anesthesia had been obtained with intravenous administration of 64 mg. of sodium pentobarbital per five pounds body weight, the animal was subjected to laparotomy under aseptic technique. Massive resection of the small intestine was performed, leaving in each instance approximately four to five inches of proximal jejunum and the same length of terminal ileum. End-to-end anastomosis was done, using chromic catgut for mucosa and muscular layers and fine black silk for serosa. The abdomen was routinely closed without drain.

In some instances, parenteral fluids were given for three to five days postoperatively to restore fluid balance. Water was allowed by mouth immediately, but no food for three or four days. A standard diet of raw meat and dog biscuit was then offered all animals, and water *ad libitum;* weights were recorded frequently.

Blood samples were obtained from the femoral vein preoperatively, and at various intervals postoperatively.

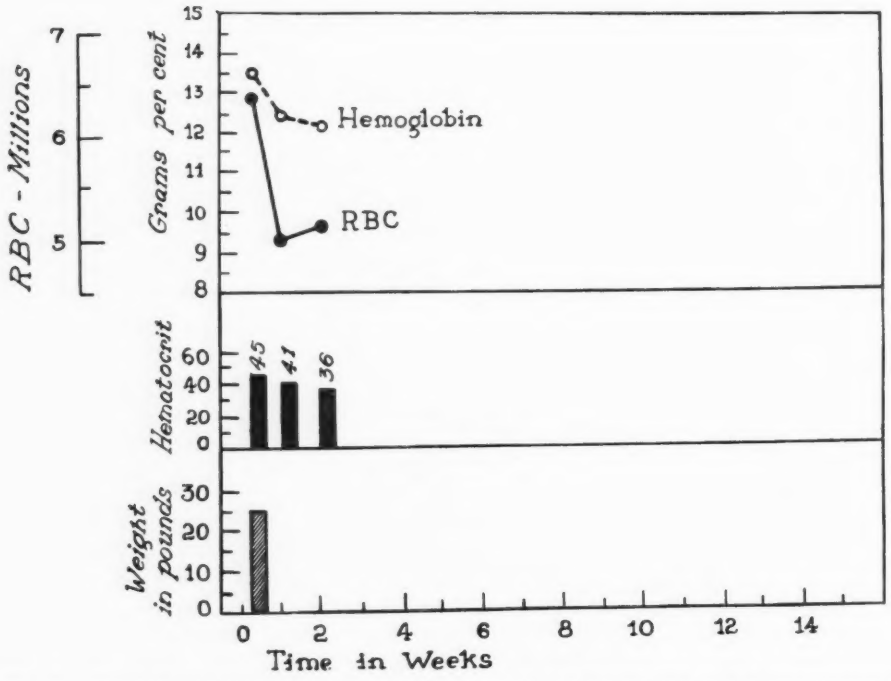


Fig. 2.—Chart demonstrating the drop in blood count and hematocrit in the experimental animal, following the resection of the intestines.

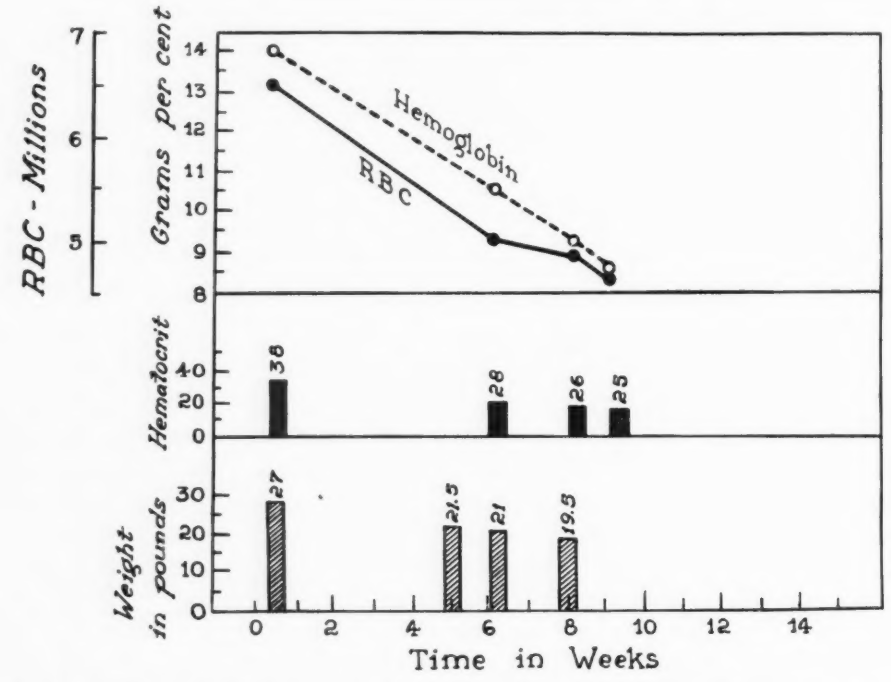


Fig. 3.—Chart of blood findings in an animal showing a marked drop but over a more prolonged period, following resection of the intestines.

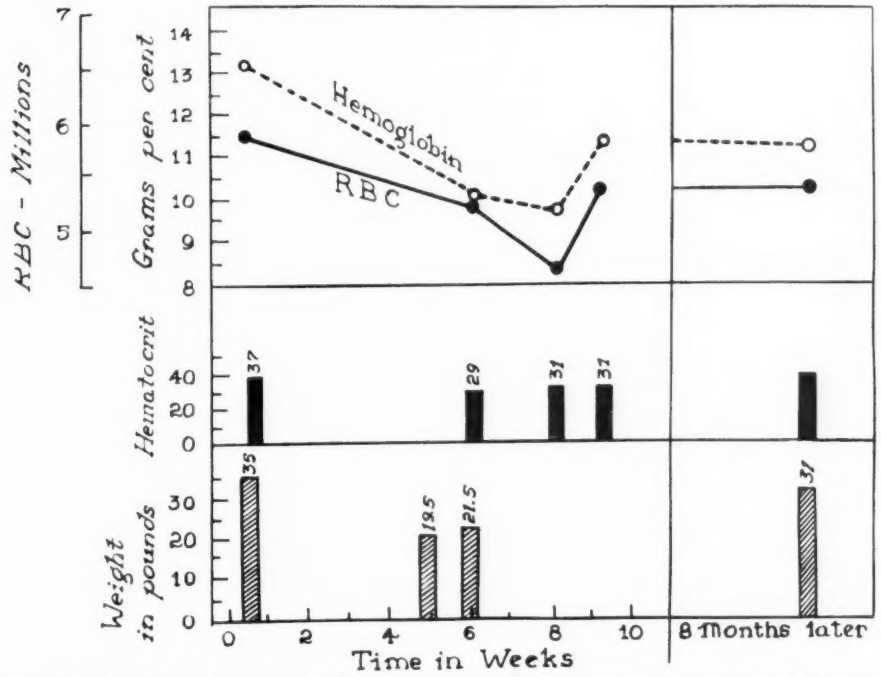


Fig. 4.—Chart showing the characteristic early findings and also late findings following resection of the small intestine. It is noted that at the end of eight months the blood count and hemoglobin are within normal limits on usual diet.

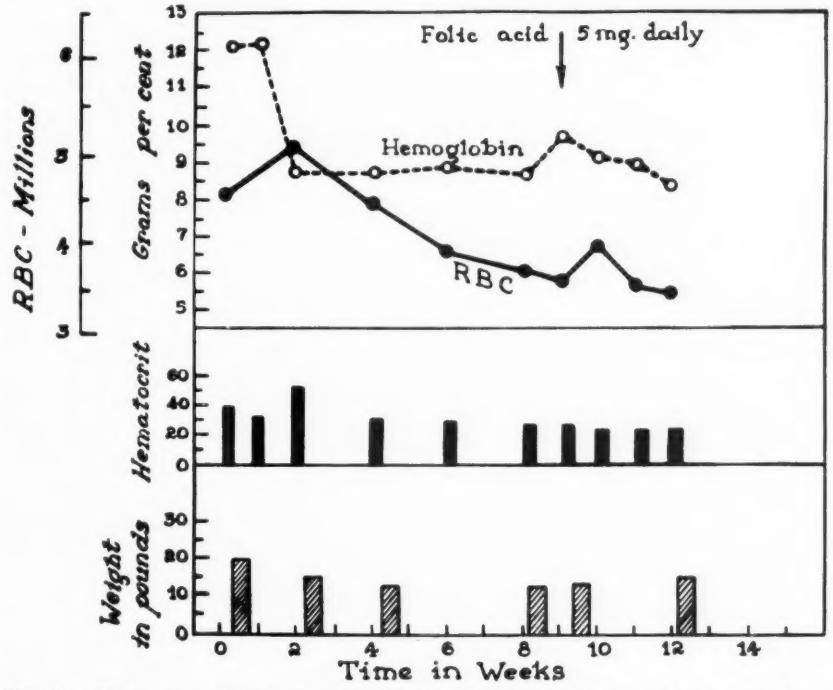


Fig. 5.—Chart demonstrating the failure of the correction of the anemia produced when intestines are resected by the administration of folic acid.

Erythrocyte counts were made; hemoglobin content was read from the Sanford-Sheard photelometer; and hematocrit was determined by the Wintrobe method. Wet and permanent preparations stained with brilliant cresyl blue for reticulocyte counts were made, and these reported as per cent after a count of 1,000.

## RESULTS

Of twelve animals having massive resections, only four survived a sufficient length of time for study. A majority of the postoperative deaths occurred in the first seven to ten days following resection, and were due to dehydration and malnutrition. Autopsy revealed no deaths due to peritoneal infection or leakage of the anastomosis.

In the animals which survived for a month or more, a characteristic pattern of events was noted. At first, hemoconcentration occurred due to dehydration from diarrhea and low fluid intake. After adequate fluid intake was resumed, approximately normal counts were obtained. Three to four weeks postoperatively, however, red cell count and hemoglobin began dropping progressively to low levels, at which they were maintained. Reticulocytes were extremely low or absent. (The normal reticulocyte count for the dog is 3 to 5 per cent.) Weight began to decline postoperatively, and after a 25 to 40 per cent reduction, remained fairly stable. The animals took on the appearance of chronic malnutrition, and one of them particularly showed a characteristic loss of hair over the extensor surfaces and head, with skin changes similar to those seen in pellagra.

Changes in volume and color indices were not constant, and no definite trend toward macrocytosis could be established. Present in all, however, was the marked lowering of hemoglobin and erythrocyte count, with low reticulocyte counts.

No response was noted in the animals treated with folic acid, 5 mg. daily by mouth. Most of the animals retained good appetites and consumed normal or greater than normal quantities of food, passing large semiformed light-colored stools.

## CONCLUSION FROM EXPERIENCES

Massive resection of small intestine in the adult dog produces a marked state of malnutrition with a resultant anemia. This anemia is not constant as to type. Lack of significant changes in color indices would seem to indicate that iron stores were adequate. Iron taken in the diet as myoglobin and hemoglobin was adequate to prevent iron deficiency. Also, adequate amounts of proteins were given in the diet, but not absorbed.

The acuteness of the state produced in the experimental animal does not lend itself well for comparison with clinical cases, inasmuch as the time intervals involved are different. Lack of response to folic acid suggests that the severe anemia produced in the animal is not entirely upon the same basis as that in the clinical cases. Perhaps more restricted resections over longer intervals might more nearly produce anemias of a macrocytic type which would show response to folic acid.

SUMMARY

1. A report of two patients who developed anemia following extensive resection of the intestines is presented.

2. A review of the literature has been made, and theories regarding the etiologic basis for hyperchromic macrocytic anemia are discussed chronologically.

3. Extensive resections of the small intestine were performed in a series of experimental animals in an attempt to reproduce the hyperchromic macrocytic anemia observed in clinical patients following similar operative procedures.

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# EFFECT OF ABSORBABLE SPONGES ON INFECTION

## Experimental Study

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AN ABSORBABLE agent for hemostasis was first employed by Cushing[1] in the form of a strip of muscle tissue. Grey,[2] 1915, and Harvey,[3] 1916, introduced fibrin for the same purpose, while fibrin foam was recommended by Ingraham and Bailey.[4] The employment of absorbable material for hemostasis was placed on a practical basis since the introduction of synthetic materials such as oxidized cellulose (Unruh and Kenyon[5]), and gelatin (Correll and Wise[6]). Numerous investigators[7-14] confirmed the value of such products for hemostasis in various fields of surgery. The popularity of the absorbable sponges suggested the question whether the presence of infection should be considered a contraindication to their use. We attempted to study the problem in the following manner. A culture of pathogenic microorganisms was implanted into subcutaneous pockets in dogs, and the question was studied whether the infection is intensified by placing absorbable sponges into the same pockets.

### EXPERIMENTS

The experiments were divided into four groups. In the first group the question was investigated whether sponges alone cause an infection. In the second group sponges and bacteria were implanted together to see whether absorbable material intensifies infection. The third group was concerned with the question whether local application of penicillin is able to suppress the intensification of infection, if any, by absorbable sponges. In the fourth group the local application of penicillin was replaced by an injection of penicillin at a remote place.

In the first series 4 dogs were anesthesized with subcutaneous morphine injections, followed by intravenous administration of nembutal. The skin on the abdomen was shaved and prepared with iodine followed by alcohol. Four pararectal incisions 2 cm. in length and 5 cm. apart were made. The edges were undermined and in each pocket an identical amount, namely .03 Gm. of absorbable cotton,* fibrin foam,† Gelfoam,‡ or Oxycel,* respectively, was placed. The incisions were closed with interrupted silk sutures. The dogs were killed seven days later and the sites of insertion of sponges were opened under sterile conditions. The gross inspection failed to reveal any signs of infection. Agar cultures after one week incubation period remained negative. The experiments showed that under conditions employed, absorbable sponges alone did not create any infection.

In the second series of experiments 12 dogs were employed, using the same technique as in the first series. Through a right pararectal incision, serving as

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*Supplied by Parke, Davis & Company, Detroit, Mich.

†Supplied by Cutter Laboratories, Berkeley, Calif.

‡Supplied by The Upjohn Company, Kalamazoo, Mich.

TABLE I

| DOG | CONTROL | | | COTTON | | | FIBRIN-FOAM | | | GELFOAM | | | OXYCEL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | |
| | | − | + | | − | + | | − | + | | − | + | | − | + |
| 1 | − | x | | P | | x | S | | x | S | x | | S | | x |
| 2 | − | x | | − | x | | S | x | | − | x | | S | | x |
| 3 | − | x | | − | x | | S | | x | − | x | | S | | x |
| 4 | − | x | | S | x | | S | x | | S | x | | S | x | |
| 5 | − | x | | S | x | | S | | x | S | | x | S | | x |
| 6 | − | x | | − | x | | S | | x | − | x | | S | | x |
| 7 | − | x | | S | | x | − | x | | − | x | | − | x | |
| 8 | − | x | | − | x | | S | | x | − | | x | S | | x |
| 9 | − | x | | P | | x | P | | x | P | | x | P | | x |
| 10 | − | x | | P | | x | P | | x | P | | x | P | | x |
| 11 | S | x | | S | | x | S | x | | S | | x | S | x | |
| 12 | − | x | | − | x | | S | x | | − | x | | S | x | |
| Total | 1 | 12 | 0 | 7 | 7 | 5 | 11 | 5 | 7 | 6 | 7 | 5 | 11 | 4 | 8 |

S = serous; P = purulent; + = positive; − = negative.

a control, 0. 2. c.c. of a virulent staphylococcal culture was implanted into a subcutaneous pocket. On the left side four incisions were made, the same amount of culture was placed into each pocket and a piece of absorbable cotton, fibrin foam, Gelfoam, or Oxycel, respectively, was inserted. The results recorded in Table I show that of 12 controls, the macroscopic inspection disclosed a serous exudate only in one instance. All the cultures were considered negative because the number of colonies, if any, did not exceed 1 to 3 and this was probably caused by contamination. Of 12 pockets containing absorbable cotton, 3 showed a purulent and 4 a serous exudate. Five cultures had numerous colonies. Of the 12 pockets containing fibrin foam, 2 had a purulent and 9 a serous exudate, while 7 had numerous colonies. Of the 12 pockets containing Gelfoam, 2 had a purulent exudate and 4 serous exudates, while 5 cultures had numerous colonies. In the 12 Oxycel pockets, there were 2 purulent and 9 serous exudates, with 8 cultures having numerous colonies.

The third series of experiments, employing 10 dogs, was a repetition of the second series, but after insertion of the sponges, each was moistened with 100,000 units of penicillin.* The results (Table II) show that of the 10 control pockets,

TABLE II

| DOG | CONTROL | | | COTTON | | | FIBRIN-FOAM | | | GELFOAM | | | OXYCEL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | | EXUDATE | CULTURE | |
| | | − | + | | − | + | | − | + | | − | + | | − | + |
| 1 | − | x | | S | x | | S | x | | − | x | | − | x | |
| 2 | S | x | | S | x | | S | x | | − | x | | S | x | |
| 3 | − | x | | − | x | | − | x | | − | x | | − | x | |
| 4 | S | x | | P | | x | P | | x | S | x | | P | | x |
| 5 | S | x | | S | x | | S | x | | S | x | | S | x | |
| 6 | − | x | | S | x | | P | | x | S | x | | S | x | |
| 7 | − | x | | S | x | | S | | x | − | x | | − | x | |
| 8 | − | x | | S | | x | S | | x | − | x | | − | x | |
| 9 | − | x | | S | x | | S | | x | − | x | | S | x | |
| 10 | − | x | | S | x | | S | x | | P | x | | − | x | |
| Total | 3 | 10 | 0 | 9 | 8 | 2 | 9 | 5 | 5 | 4 | 10 | 0 | 5 | 9 | 1 |

*Supplied by Commercial Solvents Corporation, New York, N. Y.

3 contained serous exudates but all cultures were negative. Of the 10 pockets with cotton, 1 had a purulent and 8 a serous exudate, and 2 cultures had numerous colonies.

Of the 10 pockets with fibrin foam, 2 contained purulent and 7 serous exudates. Five of the cultures contained numerous colonies. Of 10 pockets with Gelfoam, 1 had a purulent and 3 a serous exudate. All cultures were negative. The Oxycel group had 1 purulent and 4 serous exudates, with 1 positive culture.

In the fourth series of experiments a similar procedure was employed but instead of a local application of penicillin, 300,000 units in oil were administered intramuscularly at a certain distance from the incisions. The results are shown in Table III. The control pockets in the 10 dogs contained no exudates and the cultures were negative. Of the 10 pockets with cotton 1 had a purulent and 3 a serous exudate, while only 1 culture was positive. Of the 10 pockets with fibrin foam, 1 had a purulent exudate and 3 serous exudates, although no cultures were positive. Of 10 pockets with Gelfoam, 2 had serous exudates. All cultures were negative. Of the 10 pockets with Oxycel, 1 had a purulent and 5 a serous exudate, but no cultures were positive.

TABLE III

| | CONTROL | | | COTTON | | | FIBRIN-FOAM | | | GELFOAM | | | OXYCEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EXU- | CULTURE | | EXU- | CULTURE | | EXU- | CULTURE | | EXU- | CULTURE | | EXU- | CULTURE |
| DOG | DATE | − | + | DATE | − | + | DATE | − | + | DATE | − | + | DATE | − | + |
| 1 | − | x | | − | x | | − | x | | − | x | | S | x | |
| 2 | − | x | | − | x | | − | x | | − | x | | − | x | |
| 3 | − | x | | S | x | | S | x | | S | x | | S | x | |
| 4 | − | x | | S | x | | S | x | | S | x | | S | x | |
| 5 | − | x | | S | x | | P | x | | − | x | | S | x | |
| 6 | − | x | | − | x | | − | x | | − | x | | S | x | |
| 7 | − | x | | − | x | | − | x | | − | x | | − | x | |
| 8 | − | x | | P | | x | − | x | | − | x | | P | x | |
| 9 | − | x | | − | x | | − | x | | − | x | | − | x | |
| 10 | − | x | | − | x | | S | x | | − | x | | − | x | |
| Total | 0 | 10 | 0 | 4 | 9 | 1 | 4 | 10 | 0 | 2 | 10 | 0 | 6 | 10 | |

## COMMENTS

The experiments showed that absorbable sponges have a tendency to intensify an infection created in subcutaneous tissues of dogs by *Staphylococcus aureus*. This tendency was slightly more pronounced in certain brands of absorbable sponges than in others. Moistening of the absorbable material with penicillin did not inhibit this effect, which, however, could be eliminated by concurrent administration of penicillin in oil intramuscularly. Only *Staph. aureus* was employed in the experiments. It is realized that infections caused by other pathogenic microorganisms may not be intensified by absorbable sponges.

As far as abdominal surgery is concerned, this undesirable effect of synthetic hemostatic agents may be of no practical importance in infections of the peritoneal cavity because, as a rule, the defensive processes of the peritoneum are greater than those of subcutaneous tissues. However, the results of the experiments suggest the use of penicillin-in-oil in cases where absorbable sponges are

employed in presence of an infection, or in cases where the development of an infection during the postoperative period is feared. It is probable that an aqueous solution of penicillin would be just as effective as penicillin-in-oil in the inhibition of infection, but since we used penicillin-in-oil (thus eliminating frequent injections), our conclusions are based on that type of administration.

## SUMMARY

1. Experiments on dogs showed various brands of absorbable sponges to have a tendency to intensify infection created in subcutaneous tissues by *Staph. aureus*.

2. Moistening of absorbable sponges with penicillin was not able to prevent this effect.

3. Intramuscular administration of penicillin-in-oil inhibited the intensification of infection caused by absorbable sponges.

4. Administration of penicillin-in-oil is recommended whenever absorbable sponges are employed in presence of a manifest or anticipated infection.

We wish to express our gratitude to Dr. Warren H. Cole for his valuable suggestions and the privilege of performing the experiments in the laboratory of the Department of Surgery, University of Illinois, College of Medicine.

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# COMPLICATIONS OF IMPERFORATE ANUS REPAIR

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IMPERFORATE anus repair has advanced so that in most instances the entire procedure is done from the perineal approach. X-ray localization of the blind pouch, taken with the child in an inverted position (Fig. 1), has particularly stimulated primary repair. A preliminary colostomy is practically never necessary. When extensive dissection is required in the newborn infant, particularly in instances where the blind end of the colon is high, technical complications are likely to occur.

## URINARY TRACT INJURIES

In the male infant the urethra and bladder are especially endangered. In one instance, the urethra was snapped at the junction with the bladder, the prostate remaining in place.

*Prophylaxis.*—A small urethral catheter should be passed into the bladder and anchored to the prepuce with a suture. This serves as a guide by palpation, and also by visualization if the thin urethra is approached closely or actually entered.

Also, the urethra is splinted by the catheter and is less likely to be torn by traction on the surrounding structures. This is important at the urethrovesical junction, because the prostatic urethra is fixed by strong fascia, and the bladder can be pulled away from it.

*Repair.*—A small laceration of the urethra would require only the indwelling catheter for about ten days.

In the instance where the bladder was pulled away from the prostatic urethra no catheter had been anchored preoperatively. The internal urethral orifice was seen as a small aperture in the bladder, no urethra being attached. The distal end, or prostatic urethra, was not visible through the incision.

A catheter was passed through the penis and became visible from behind the symphysis pubis. The catheter was passed into the bladder through the aperture (internal urethral orifice) and anchored with a single suture.

The catheter was withdrawn from the penis to the limit of gentle traction and anchored to the glands with a suture (Fig. 2). This replaced the bladder and urethra in their proper relationship. Healing occurred without early or late complications.

## SEPARATION OF ANAL SUTURE LINE

The anastomosis of the mucosa to the anal skin should hold and primary union take place. When the blind end is unusually high, partial or complete separation sometimes occurs.

*Prophylaxis.*—The essential factor in primary union is the absence of tension on the suture line. The pouch must be mobilized freely so that it falls into position against the anal skin.

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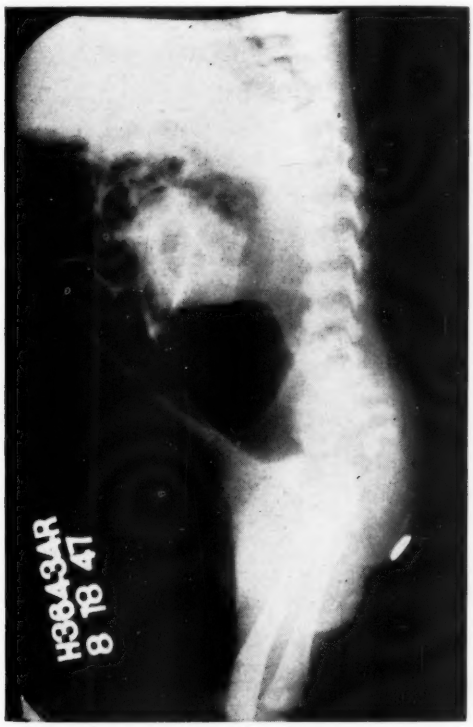


Fig. 1.—X-ray taken in an inverted position; end of blind pouch seen as shadow at third sacral segment, marker is at usual position of anus.

Fig. 2.—Replacement of bladder by traction on catheter anchored to bladder neck.

The wall of the bowel must be preserved by gentle handling. It is particularly difficult to compensate for any defects resulting from tearing by undue traction.

*Repair.*—When part of the circumference of the anastomosis separates, a stricture results. Postoperatively, frequent dilations are necessary for a considerable period. These patients must be followed closely and dilatation done

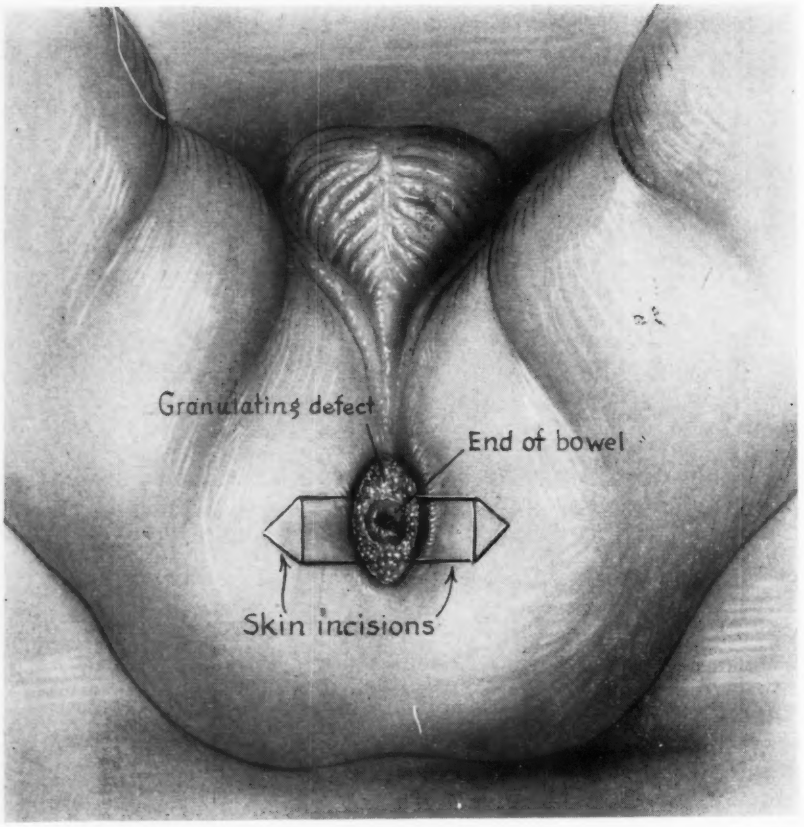


Fig. 3.—Incisions for pedestal graft; the rectangular areas form the skin tube, the triangular areas are excised to permit transverse closure.

with the gloved finger at least once a week for several months. At the early dilatations there will be some tearing of the stricture with bleeding. The lumen gradually enlarges, probably due to growth of the mucosa over the raw surface for a small distance each time the stricture is dilated. At about the age of 6 months the lumen remains large and frequent dilatations are no longer necessary. There should be a checkup at regular intervals for several years to guard against recurrence of the stricture.

If the anastomosis separates completely, a plastic pocedure to form a skin-lined anal canal may be necessary. This may be done before healing of the resulting defect begins. The bowel is seen as a ring of mucosa in the depths of a trough lined by granulation tissue. The separation causes the skin edges to retract so that the gluteal crease is obliterated.

At the secondary operation an incision outlining a rectangular area of skin is made on each side (Fig. 3). This incision is carried down to mobilize this area from the surrounding skin but is left attached on its deep surface to the subcutaneous tissue. A rectangular area of skin thus rests on a pedestal of subcutaneous tissue. This pedestal graft is freely movable in all directions and can be placed against mucosa of the bowel without traction (Fig. 4). The resulting defect in the gluteal area is closed, holding the pedestal grafts on each

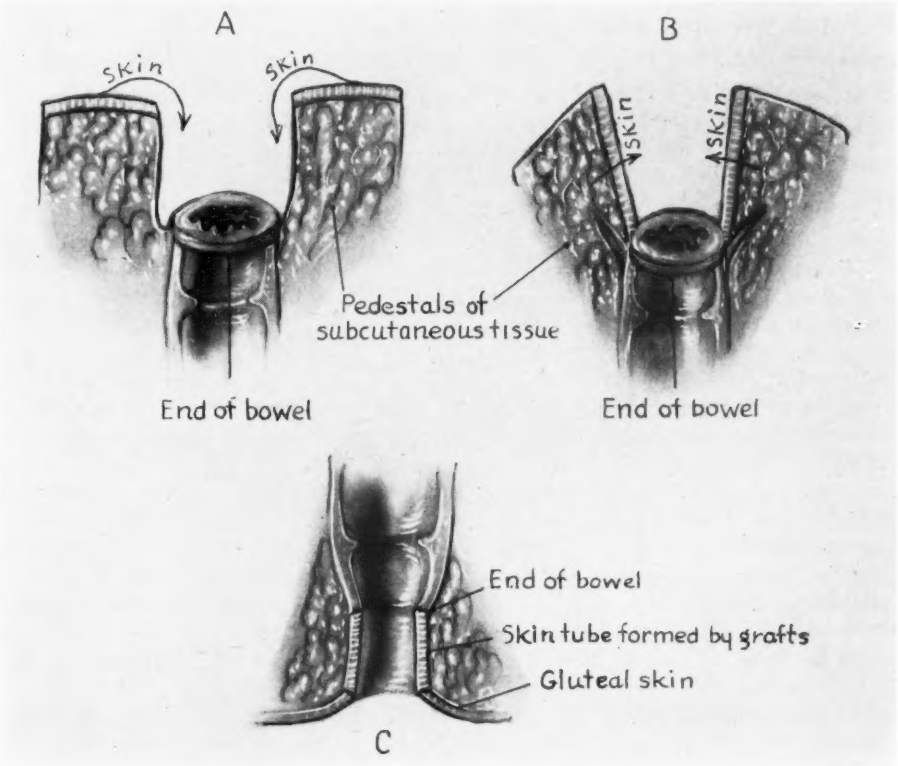


Fig. 4.—*A*, Pedestal graft prepared; *B*, pedestals bent, forming skin tube; *C*, end result.

side in position. No suturing of the skin to the mucosa is necessary. The grafts are not sutured to each other but fall into position as healing of the defect anteriorly and posteriorly occurs, forming a skin-lined tube. The outer portion of the grafts are anchored to the skin margins.

A careful postoperative dilatation regime is essential to prevent the deep end of the skin tube from growing together and to overcome any stricture formation at the junction of skin tube and mucosa.

## SUMMARY

Certain complications of imperforate anus repair are presented and methods of prophylaxis and treatment are suggested. The use of a pedestal graft is introduced.

# A GANGLION OF THE ANTERIOR CRUCIATE LIGAMENT

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ALTHOUGH ganglia are found with relative frequency in the periarticular tissues of the knee, the presence of a ganglion on a cruciate ligament is very uncommon. A review of the literature has revealed only two cases in which the formation of a ganglion on a cruciate ligament has been noted.[2,8] The following case is, therefore, reported because of its rarity and because it appears to be the first of its kind to be described in the English literature.

## CASE REPORT

The patient, a 23-year-old white man (Reg. No. 95633), was admitted to the Orthopedic Section of the Kingsbridge Veterans Administration Hospital on May 21, 1947, with the complaint of weakness and recurrent attacks of pain in the left knee for three years. In September, 1944, he had fallen into a shell hole at night while in combat in Italy and twisted the left knee. He had immediate pain and swelling which required his evacuation to a hospital where he was placed in a long leg plaster for three weeks. He was then given physiotherapy for three more weeks and at the end of that period was well enough to return to full duty. Thereafter, he had only occasional attacks of relatively mild pain and swelling until January, 1947, when the left knee suddenly buckled while he was walking on even pavement. This occurred about once monthly from then until May 13, 1947, when, while playing baseball, the knee gave way again as he made a sudden turn. While the knee did not lock, he was unable to extend it fully for about thirty minutes because of severe pain, but at the end of that time he was able to straighten the knee and walk. Swelling occurred within two hours. He stayed at home for the following week under the care of a physician, but when he failed to respond to conservative therapy he was admitted to the hospital for further treatment.

Physical examination on admission revealed that the patient walked with a limp favoring the left leg. There was one inch atrophy of the left thigh with corresponding diminution of tone in the left quadriceps. There was a moderate amount of fluid in the left knee. Range of motion was complete but there was some pain referred to the medial aspect of the knee joint on full flexion. No relaxation of the collateral or cruciate ligaments was found. There was tenderness to pressure over the anteromedial aspect of the knee joint.

X-ray findings, including a tunnel view and tangential view of the patella, were negative. Urinalysis, blood count, serology, and sedimentation rate were not remarkable.

Although osteochondritis dissecans of the patellae appeared likely, no definite diagnosis was established preoperatively. An exploration of the knee seemed advisable. On May 28, 1947, an arthrotomy was performed under spinal anesthesia using a median parapatellar incision. A thin-walled cyst, about 2 cm. in diameter, was noted projecting anteriorly into the intercondylar notch from its attachment to the lower third of the anterior cruciate ligament. The cyst was carefully dissected free. The anterior cruciate ligament was still intact and strong after it was removed. The articular surface of the patella was then examined and the entire medial half was found to be involved in an osteochondritic process with actual

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"sequestra" of cartilage present. All diseased cartilage was removed down to bleeding bone except for a circular area about 2 cm. in diameter in the center of the diseased area in which the bone was so dense and eburnated that it did not bleed even when drilled quite deeply. No other abnormality was found.

The cyst consisted of one large and one small loculus which did not communicate with each other. It contained thick, gelatinous material. Microscopic examination revealed typical ganglion structure with the wall formed of concentric layers of flat-celled fibrous tissue and no true endothelial lining (Figs. 1 to 3).

The postoperative course was uneventful. Quadriceps setting exercises were begun twenty-four hours after surgery, sutures were removed on the tenth day, and weight-bearing was begun on the twelfth day. Full range of motion was regained in twenty days. The patient was able to return symptom-free to employment as a stock clerk after thirty days.

Fig. 1.—Anterior surface of cyst. Fibers of the anterior cruciate ligament can be seen above the cyst. Parallel marks at the lower edge were caused by the forceps with which the cyst was grasped during operation.

While at first glance this cyst, projecting into the intercondylar notch, appeared to be intra-articular and so did not meet the criteria for a ganglion, its origin from the anterior cruciate ligament made it the characteristic extra-articular lesion albeit in an unusual location. It is this unusual aspect of the case which may serve to shed some light on the prevailing theories of the etiology of ganglia. These theories have been discussed by several authors.[3,7] Those given the widest credence today are:

1. Metaplasia of specialized periarticular connective tissue so that it develops a secretory action forming a pseudojoint cavity (King)

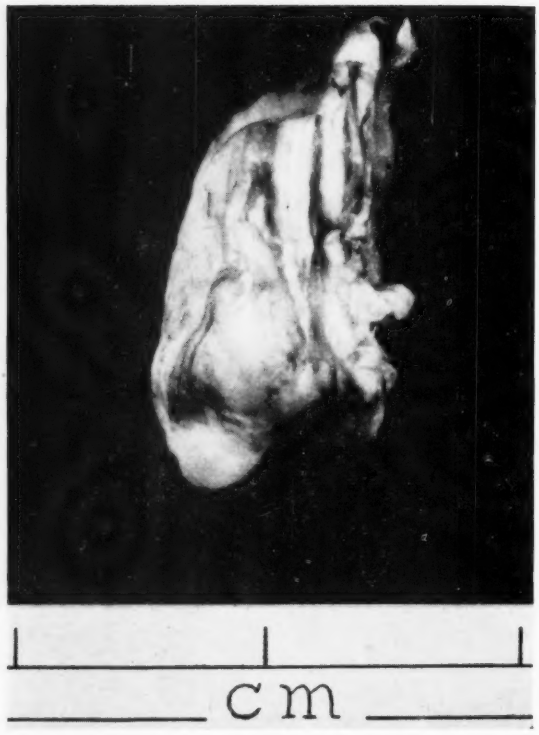


Fig. 2.—Posterior surface of cyst; some fibers of anterior cruciate ligament are still attached.

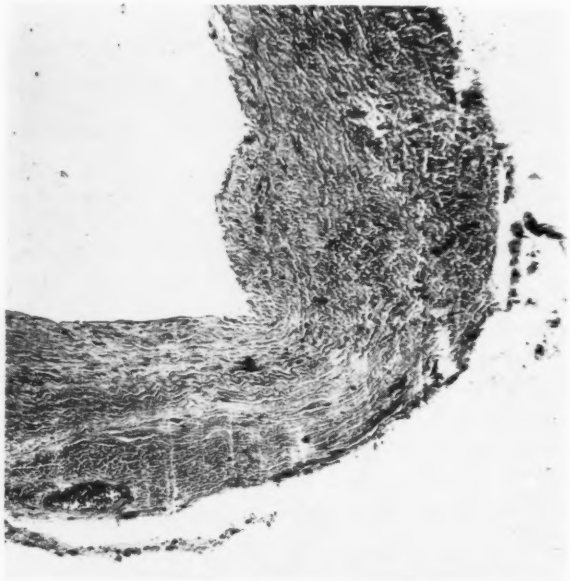

Fig. 3.—Section of cyst wall (×80) showing characteristic ganglion formation; note lack of true endothelial lining.

2. Synovial rests in the developing periarticular connective tissue later form ganglia (Harrison)
3. Herniation of the synovial lining of a tendon sheath or joint capsule (Eller, Doyle)
4. Myxomatous degeneration of specialized periarticular connective tissue forming a pseudocyst (Ledderhose).

Doubt has been cast before[4] on the accuracy of King's theory since, by the use of Mayer's mucicarmin stain, it has been shown that the contents of ganglia are myxoid and thus due to a degenerative process rather than mucinous and a true secretion. The same argument would hold against Harrison's theory.

In our case at least is seems unlikely that herniation of the synovial lining occurred. The density and strength of the anterior cruciate ligament make it unlikely that this would happen. It seems more likely that the ganglion formed in a local area of degeneration. Whether this was due to a congenital abnormality of the ligament or to the trauma which he suffered cannot be definitely ascertained. However, the fact that most ganglia form in other locations, with no definite history of trauma, makes it appear unlikely that injury was an important factor.

We could establish no definite causal relationship between the existence of the ganglion of the anterior cruciate ligament and the osteochondritis of the patella, unless the abnormal mechanics of the knee extension apparatus due to the osteochondritis precipitated degenerative changes in the anterior cruciate ligament. In this event our hypothesis would still hold true.

The symptoms of a ganglion of a cruciate ligament do not appear to be constant. The limited experience with this entity has revealed a wide range of complaints in the two previously reported cases from no symptoms at all to severe disability.

In 1924 Caan[2] reported a case which was completely asymptomatic. The ganglion was an incidental finding in the knee of a cadaver which was being subjected to a knee resection during a course in cadaver surgery. A review of the patient's medical history revealed no complaint referable to the knee. The pathologic findings consisted of one hazelnut-sized, unilocular ganglion in the middle of the anterior cruciate ligament completely covered by dense fibers except in one small area where the cyst wall projected beyond the fibers. In addition, two smaller ganglia, completely separate from the first, were found within the anterior cruciate ligament. None was found anywhere else in the body.

Sjövall's case,[8] reported in 1942, was that of a 21-year-old woman who, ten years prior to hospitalization, had had an episode of unexplained effusion in the left knee. There was no preceding trauma or illness and the only symptom at that time was tension in the knee. It disappeared after three weeks of bed rest. She remained symptom-free until six years later when she jumped during a game of volley ball and, while in the air, felt severe pain in the left knee. The knee did not lock but there was severe pain along the medial aspect of the joint line and an effusion soon developed. After three weeks the effusion sub-

sided but the pain persisted in the same place. She had to give up all forms of athletics and even walking caused some pain. Four years later, when she was finally hospitalized, there was no effusion noted but there was some quadriceps atrophy and definite genu recurvatum. There was point tenderness over the anteromedial aspect of the knee joint. X-ray findings were negative. At operation a multilocular ganglion, "about the size of two beans," was found arising from the posterior cruciate ligament at the point where it was partially detached from the tibia. The ganglion was removed but no attempt at repair of the ligament was made because most of the fibers were intact. The postoperative course of the case was not discussed in this paper.

Sjövall felt that the ganglion had antedated the onset of symptoms and probably weakened the posterior cruciate ligament sufficiently to cause a partial rupture of it when the knee was exposed to relatively mild trauma.

In our case the role played by the ganglion in the causation of symptoms was so clouded by the presence of the extensive osteochondritis of the patella that any attempt to form definite conclusions would seem unjustified. The latter finding alone could have caused all the complaints. However, at the time of operation, it was deemed advisable to remove the ganglion. We felt that it might eventually have involved more of the anterior cruciate ligament, weakening it sufficiently to cause disability, or that it might grow large enough to obstruct the movements of the knee.

## SUMMARY

A case has been presented in which a ganglion of the anterior cruciate ligament and osteochondritis of the patella were found. The ganglion was probably formed in a localized area of degeneration in the anterior cruciate ligament. None of the symptoms could be attributed definitely to the ganglion but it was removed because it was potentially harmful. This appears to be the third case of a ganglion of a cruciate ligament to be described.

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# CONGENITAL ATRESIA OF THE ESOPHAGUS WITH HYPOPLASIA OR AGENESIS OF THE LOWER SEGMENT

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*(From the Department of Surgery, University of Michigan Hospital, Ann Arbor, Mich.)*

CONGENITAL atresia of the esophagus is now recognized as a common anomaly. The relative incidence of this congenital defect has been discussed by Haight,[1, 3] and by Ladd and Swenson.[2] Haight estimated that the anomaly occurs once in each 2,196 births. The diagnosis, if the clinician is alert to the possibility of its presence, is easy. The observation that the infant is unable to swallow, that it regurgitates immediately all fluid offered, and that choking, dyspnea, and cyanosis occur should make the diagnosis probable. Confirmation of the diagnosis is obtained when a soft rubber catheter (8 or 10 French) fails to pass into the stomach.

A few drops of lipiodol injected into the catheter will either delineate the upper segment as a blind pouch (the common finding), demonstrate a fistulous communication between the upper segment and the trachea (a rare anomaly), or indicate that esophageal continuity through a strictured area is present (a still rarer type of defect).

In addition to demonstrating the presence or absence of atelectasis or pneumonia, the x-ray film will reveal the presence or absence of air in the stomach or intestine. It is with the cases of atresia, in which no air is visible in the stomach, that this discussion is concerned. When air is present it indicates that a tracheoesophageal fistula is present, that the lower segment of the esophagus is patent, and that it extends as high as the tracheal bifurcation. (Haight reported a case in which the fistulous communication was between the esophagus and the right main stem bronchus.) These patients may, therefore, be considered as suitable candidates for a right-sided extrapleural division of the fistula and a primary esophageal anastomosis, the accumulating experience of many authors demonstrating this operation to be the procedure of choice.

The absence of air in the stomach does not necessarily mean that a tracheoesophageal fistula is not present, nor that primary anastomosis is not feasible. Haight[1] reported that in five patients without air in the stomach, two had a small but patent fistula. Four of these patients were subjected to operation and in one primary anastomosis was possible. In a subsequent paper, to be published,[4] he reports that ten of sixty-two patients with esophageal atresia had no air in the stomach. Of those, seven were subjected to operation. Anastomosis of the esophageal segments was possible in two, but the approximation of the segments was not satisfactory. In five anastomosis was not possible. For this reason, tracheoscopic examination is indicated. If this procedure also fails to demonstrate the presence of a fistula the patient should be considered unsuitable for the right-sided extrapleural approach. A decision must then be made as to whether to employ the multiple stage operation which consists of marsupialization of the superior segment, gastrostomy, and eventual construction of an antethoracic esophagus or to try to obtain direct esophagogastric continuity.

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The disadvantages of the multiple stage operation are obvious, a prolonged period of hospitalization and numerous operations being required. Ladd and Swenson[2] have used this method in forty-three patients, sixteen of whom survived. Of these sixteen patients, completion of the antethoracic esophagus has been obtained in but five at the time of their report.

An attempt to establish direct esophagogastrostomy by mobilizing the stomach and anastomosing it to the blind upper segment above the aortic arch had not been made, to my knowledge, prior to its use in the case here described. Subsequently Swenson[5] reported a case in which this procedure was successfully employed.

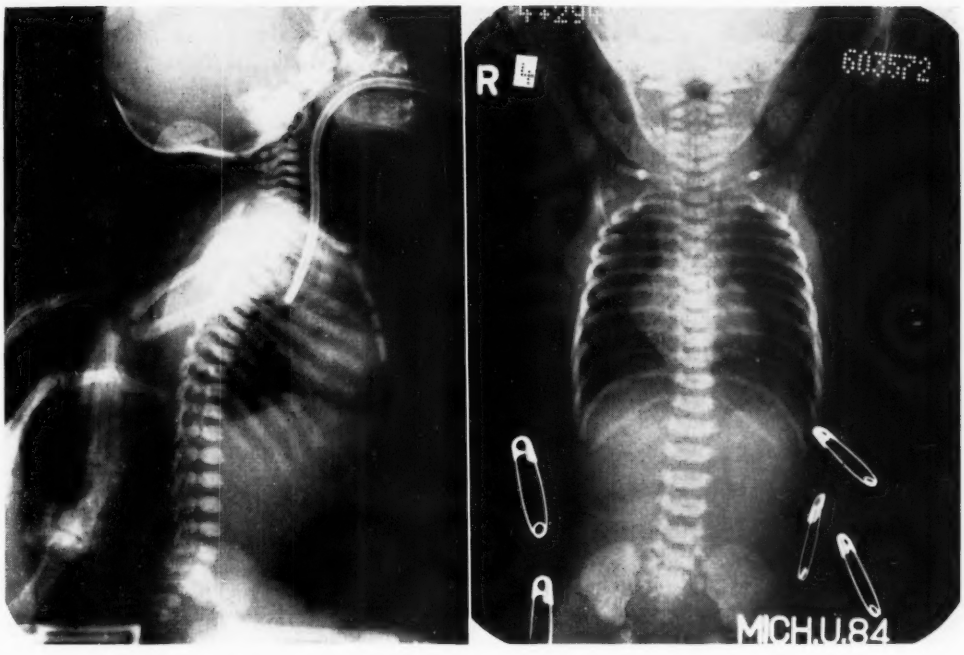
CASE REPORT

D. B., a male child, aged 4 days, was admitted to the University of Michigan Hospital on April 29, 1947. He had been delivered spontaneously after a nine-month pregnancy. Birth weight was 5 pounds, 10 ounces. He was put to breast twelve hours after birth, but became cyanotic, gagged, choked, and was obviously unable to swallow. Several feedings were attempted. A small catheter was then inserted into the esophagus and found to pass for only 10 cm. from the lips. An x-ray view confirming the presence of obstruction revealed that the lung fields were clear and that there was no air in the stomach. A diagnosis of atresia of the esophagus was made and he was referred for surgical treatment.

The physical examination, on admission, revealed that he cried lustily, becoming quite cyanotic. Cyanosis was not present, however, during normal respiration. The lung fields were clear to percussion and auscultation, and no heart murmurs were audible. There was no abdominal tympany. The state of hydration was good as he had received subcutaneous glucose solution prior to admission. An x-ray picture obtained at the University of Michigan Hospital revealed the continued absence of air in the stomach or intestine, normal lung fields, and a peculiar triangular prominence of the right heart border, the significance of which was not clearly understood.

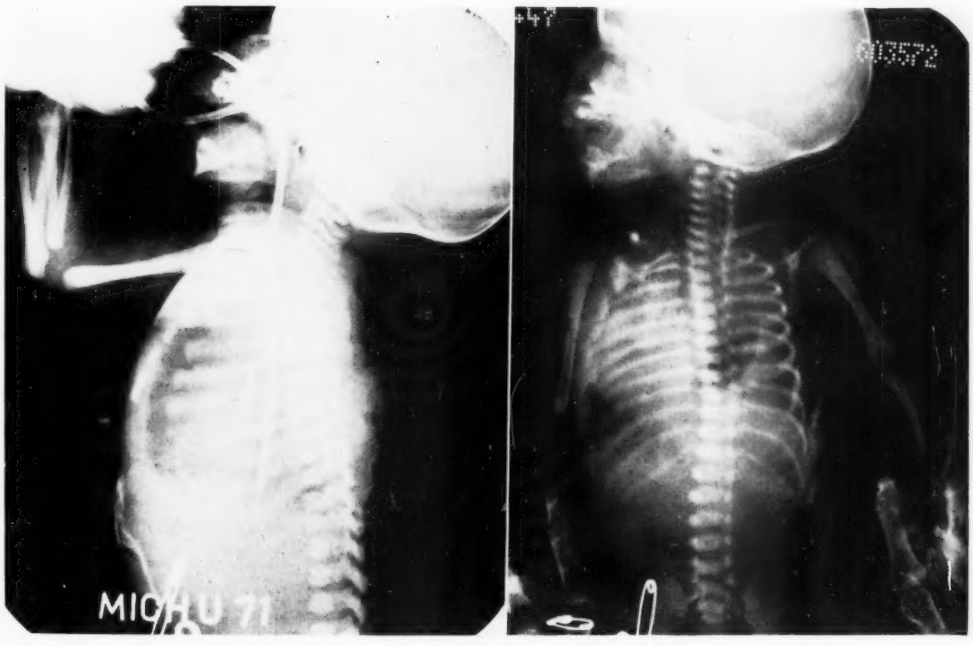
Because of the absence of air in the stomach, it was felt that marked hypoplasia or agenesis of the lower esophageal segment was present. Therefore, extrapleural anastomosis did not appear to be feasible and a left thoracotomy was decided upon. Operation was carried out under ether anesthesia on the day of admission. The ether was administered by open drop, a tight-fitting face mask being used to give oxygen under positive pressure after opening the pleural cavity. Access to the chest was through the bed of the resected seventh rib. An excellent exposure was obtained without further division of ribs. An incision was then made in the mediastinal pleura just posterior to the subclavian artery. By blunt dissection the upper esophageal segment was identified and partially delivered. It was found to be fairly thick-walled, about 1 cm. in diameter, and to end as a blind pouch just above the aortic arch. No communication existed between it and the trachea. The inferior segment was then mobilized by separating the leaves of the pulmonary ligament. It was found that the caliber was normal for only 1.5 cm. above the stomach. At this point it narrowed sharply into a fibrous cord and at the level of the inferior pulmonary vein was merely a fibrous thread. This threadlike strand continued upward beneath the aortic arch and was found to be attached to the membranous portion of the left main stem bronchus.

The diaphragm was then opened from the hiatus to the anterolateral costal attachment. The stomach was found to be very small. The first step in the mobilization of the stomach consisted in the division of the gastrosplenic ligament as close to the spleen as possible. The spleen was not removed and subsequently did not interfere with the mobilization. The gastrohepatic ligament was then divided, the left gastric artery being ligated close to its origin. When this procedure was completed the fundus of the stomach could easily be drawn to the level of the aortic arch with only slight tension. The lower segment of the esophagus was then amputated and closed by a through-and-through suture which was continued back upon itself as a seromuscular suture. A row of No. 000000 black silk sutures was then placed between the blind esophageal end and the fundus of the stomach. The end of the esophagus




*A.* *B.*

Fig. 1 (Case D. B.).—*A*, X-ray view taken the day prior to admission showing the catheter in the blind upper esophageal pouch. *B*, The posteroanterior film taken on the day of admission reveals the prominence of the right ventricle and the continued absence of air in the stomach.




*A.* *B.*

Fig. 2 (Case D. B.).—*A*, Roentgenogram taken the day following operation demonstrates the intrathoracic stomach. *B*, Oblique view on the fifth postoperative day outlines the position of the air-filled stomach.

was then opened, creating a 1 cm. stoma, and a similar incision was made in the fundus. The mucosal layers were then approximated posteriorly and anteriorly by interrupted No. 000000 silk sutures. A second anterior row of similar sutures approximated the muscular layers of the esophagus to the seromuscular layers of the stomach. A No. 10 French soft rubber catheter was then passed from above into the stomach. The stomach was fixed to the pleura overlying the vertebral bodies. The diaphragm was then closed but not sutured to the pyloric end of the stomach. The phrenic nerve was crushed. A small soft rubber catheter was employed as an intercostal drainage tube and carried to the water-seal bottle. Penicillin, 100,000 units, was instilled into the pleural cavity and the chest closed with interrupted silk sutures. There was very little blood loss during the procedure, but since the intravenous infusion had ceased to function after only 10 c.c. of blood had been given, intra-aortic injection of 20 c.c. of blood was performed midway during the operation.

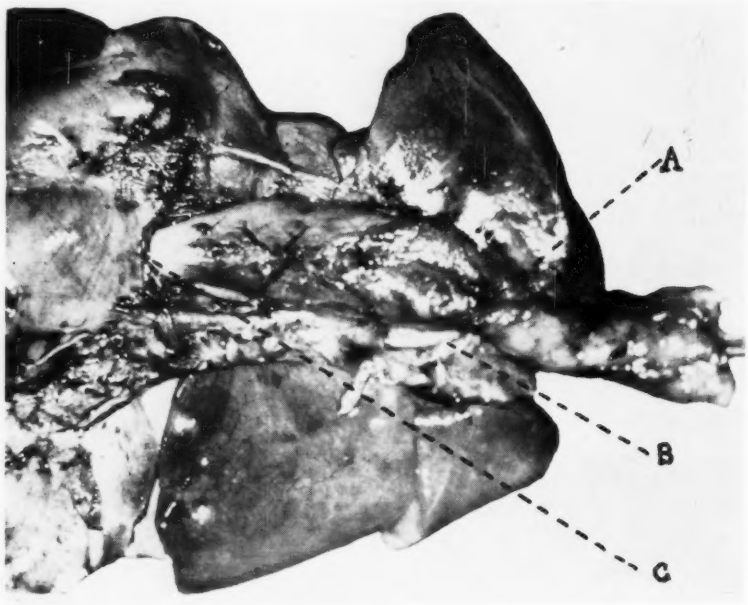



Fig. 3 (Case D. B.).—Autopsy specimen showing the well-healed line of anastomosis at the level of the aortic arch. *A*, Site of anastomosis; *B*, aortic arch; *C*, edge of diaphragm.

Postoperatively, penicillin, subcutaneous glucose (2.5 per cent), and small transfusions were given. Intercostal drainage was discontinued after seventy-two hours. The catheter was removed from the stomach after forty-eight hours. Fluids by mouth were withheld for forty-eight hours and then a few drops of 5 per cent glucose-amigen solution were given cautiously by dropper. He appeared to be able to swallow, but immediately became cyanotic. About 10 c.c. of similar solution were given by gavage feeding and this was apparently well received. However, subsequent passage of the catheter, accomplished with ease, caused the baby to cry. With each attack of crying he became extremely cyanotic and with unpleasant stimuli, such as the introduction of the stomach tube or the injection of penicillin, respirations would cease so that artificial respiration and $CO_2$-$O_2$ inhalations were required. On the night of the sixth postoperative day, a crying attack with cyanosis and cessation of respiration occurred and the nurse was unable to revive him.

At autopsy the left pleural cavity contained only a 1 cm. blood clot, the lung was expanded, and the line of anastomosis was well healed, the stoma measuring 1 cm. in diameter. The myocardium of the right ventricle was greatly hypertrophied, and was 2 mm. thicker than that of the left ventricle. What at first inspection seemed to be a double aortic arch proved to be a ductus arteriosus as large as the aorta itself. There was hypoplasia of the right and left pulmonary arteries, the ductus arteriosus being a direct continua-

tion of the main pulmonary artery. It was apparent that the chief flow of blood from the right ventricle passed directly into the aorta.

It was evident from the autopsy findings that the peculiar cardiac silhouette was due to the greatly hypertrophied right ventricle. A cardiac murmur had not been present because of the huge size of the ductus arteriosus and for the same reason a palpable aortic thrill was not present at operation.

Although this child succumbed as a result of the operation, the cardiovascular anomalies being the indirect cause of death, the case does illustrate that these infants do tolerate major intrapleural surgery and that direct esophagogastrostomy is not only feasible but can be accomplished with ease.

A few points in the operative technique seem worthy of mention. Since the gastrosplenic ligament is extremely short, the vasa brevia measuring only 2 to 4 mm. in length, care must be taken to divide it close to the spleen in order to preserve the anastomotic vessels along the greater curvature of the stomach. As the upper esophageal segment ends in a blind pouch the size of the stoma of the anastomosis is not dependent upon the caliber of the upper segment since a fishmouth incision can be made to create a stoma of any desired size. A three-layer anastomosis can be utilized but adds to the technical difficulties and the operative time, and it does not appear to be necessary. As with esophagogastrostomy in adults, resection of the seventh rib gives good exposure of the abdomen and the region of the aortic arch, thoracoabdominal incision and multiple rib resection not being required. The intra-aortic injection of whole blood, oxygenated if desired, is a positive method of mantaining blood volume.

The failure to employ tracheoscopy as a preoperative diagnostic measure in this case was a serious omission. Although the anatomic findings in this case precluded any chance of extrapleural primary anastomosis, this possibility had not been completely ruled out before operation.

## SUMMARY

In patients with congenital atresia of the esophagus in whom the x-ray examination fails to reveal evidence of air in the stomach or intestine, marked hypoplasia or agenesis of the lower segment may be inferred. An adequate lower segment may, however, be present in a small percentage of cases.

When there is failure to demonstrate air in the stomach and a tracheoscopy discloses no tracheoesophageal fistula, an extrapleural exploration seems futile and a left transpleural esophagogastrostomy is indicated.

The operation of high esophagogastrostomy in newborn infants is feasible and the operation itself was well tolerated in the case here presented. Although the infant died, death appeared to be due largely, or entirely, to the associated cardiovascular anomaly.

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# STRANGULATING DIAPHRAGMATIC HERNIA OF THE LIVER

## Report of Case With Surgical Cure

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DIAPHRAGMATIC hernia is not uncommon; its classification, symptomatology, diagnosis, and treatment have been sufficiently reported.[1, 2, 3, 4] Hernia of the right side is unusual compared with the left; the ratio is reported as 12 to 1 (Bradley[5]) and 5 to 1 (Hedblom[1]). Hernia containing only a mass of liver is rare; thus, the liver alone was found in only 14 out of 857 cases of diaphragmatic hernia.[1]

Operation was performed with resulting cure upon a patient who had both herniation of a portion of the liver through the diaphragm, and strangulation of this liver. Detailed reports of congenital, hepatic herniation treated surgically are rare and we have not been able to discover even one report mentioning strangulation of the liver. The bizarre symptoms ascribed to this hernia and its strangulation have not, to our knowledge, been previously reported.

### CASE REPORT

A 47-year-old, white housewife was seen for the first time Aug. 4, 1946, with a chief complaint of attacks of epigastric pain, nausea, and vomiting of six months' duration.

The family history revealed that the mother had died at the age of 52 years, and the father at the age of 63, both of cardiac disease, but specific character undetermined. Five sisters died in infancy of unknown causes and three sisters are living and well. There were no brothers and no contact with tuberculosis.

The past history showed diphtheria in childhood with no sequelae; there were no other childhood diseases. There had been no previous operations or accidents. The patient had been married twice and had had no pregnancies. Birth history contained no knowledge of any abnormalities. There was no history of chronic cough, repeated physical strain, or any other condition to cause increased intra-abdominal pressure.

A review of the systems showed a "nervous breakdown" in 1932 with symptoms of anxiety, nervousness, and irritability, but without gastrointestinal manifestations, and lasting two months. Recovery was complete. There had been no complaints involving the head, ears, eyes, nose, and throat. The cardiorespiratory history revealed the knowledge of a murmur since infancy, but no episodes of dyspnea, cyanosis, orthopnea, hemoptysis, pneumonia, pleurisy, or other cardiorespiratory complaints. The gastrointestinal history, until the recent illness, was negative for dyspepsia, food intolerances, constipation, or hemorrhoids. The genitourinary history was essentially negative. Venereal disease was denied by sign, symptom, and name. Catamenia: 17 by 5 by 27 without dysmenorrhea and with scanty flow; last menstrual period, July 24, 1946. She did not use tobacco or drugs, and wine only in moderation, socially. Weight had been maintained at about 147 pounds with very little fluctuation.

Illness at time of admission: The chief complaints had begun six months previously with attacks occurring on an average of once a month. The attack consisted of epigastric pain, nausea, and vomiting. The onset of the pain was gradual over a period of about five minutes, after which it reached its maximum intensity, remained constant for three to eight

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hours, was centered in a spot just beneath the xyphoid and described as "squeezing," "knotty," and "ball-like," with "cloudlike spreading to both sides" but not to the back, to the shoulders, under the sternum, nor to the scapulae. Nausea and vomiting began when the pain reached maximum intensity and was frequent throughout the attack. There was no associated diarrhea or constipation. The attacks subsided spontaneously, but could be terminated by an injection of ¼ gr. of morphine sulfate. She felt weak for one or two days following the attack but was otherwise in perfect health. She offered the information that at all times between attacks she had a feeling like a doorstop in the lower right chest which limited motion on bending forward and to the right.

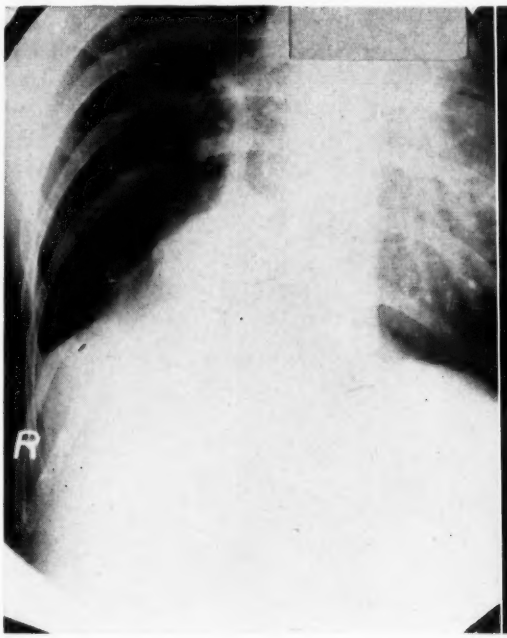


Fig. 1.

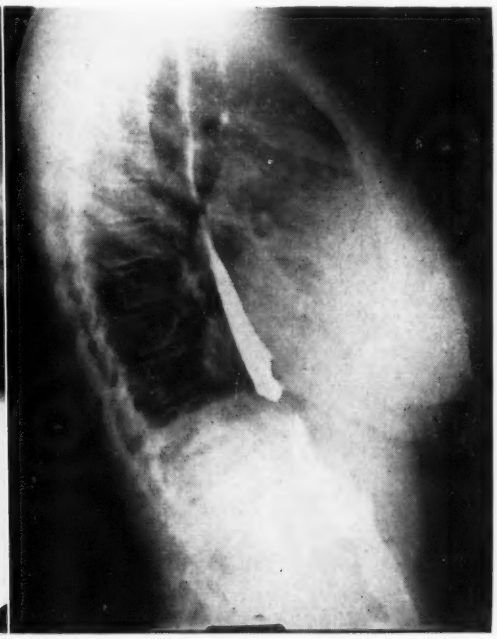

Fig. 2.

Fig. 1.—Aug. 15, 1946, x-ray picture of the chest, posteroanterior view, preoperative, showing round mass 2 inches in diameter in the right phrenicopericardial sulcus. Note the appearance as a discrete tumor as well as the displaced inferior vena cava.

Fig. 2.—Aug. 13, 1946, roentgenogram of the chest, right lateral view, preoperative, after barium swallow, showing the round mass just anterior to the tenth dorsal vertebra and not displacing the esophagus.

During the last attack, on Aug. 4, 1946, the temperature, pulse, and respirations were normal. The patient was in obvious, distressing pain. The pupils were regular and reacted to light and accommodation. The fundi were normal. There was a scar of the left tympanum. Findings for the nose, mouth, and pharynx were negative. The thyroid was normal and the trachea was in midline. There were no abnormal cervical vessels or pulsations. The lungs were clear. There were no physical signs of cardiac enlargement; the sounds were of good quality; there was a moderately loud and rough, systolic murmur heard best in the third interspace just to the left of the sternum and not transmitted in any direction; there were no thrills palpable. The blood pressure was 140 systolic and 80 diastolic. There was mild percussion tenderness over the sixth dorsal vertebra. The breasts were normal. The abdomen was soft and revealed no abnormalities except for mild tenderness high in the epigastrium on deep pressure. Pelvic and rectal examinations were essentially normal. The extremities were normal and there was no sweating. There were no hernias or adenopathy. The mucous membranes were pink. Four hours after its onset the attack was terminated within one-half hour by an injection of ¼ gr. morphine sulfate.

Diaphragmatic hernia was suspected and the patient was hospitalized for observation and investigation at the Cedars of Lebanon Hospital on Aug. 11, 1946.

While undergoing investigation the patient remained asymptomatic. The physical examination was as just described, with the deep epigastric tenderness absent. The erythrocyte count, hemoglobin, white blood cell count, and differential count were normal. The red cell morphology and platelets were normal. The sedimentation rate was 12 mm. in 146 minutes (Linzenmeier—normal, 12 mm. in 120 minutes). Blood cholesterol was 240 mg. per cent. The icterus index was 7 units (normal, 5 to 12 units). The urine was normal and showed no bile. The blood Kline reaction was negative.

Fluoroscopic examination and x-ray views of the chest (Figs. 1 and 2) showed a sharply defined, nonpulsating, globular mass thought to be in the posterior portion of the right mediastinum, just above the dome of the right diaphragm, but apparently not moving with respiration, although the diaphragm was thought to move freely. The mass measured about 7 cm. in diameter and had no apparent connection with mediastinal structures. Oral cholecystography showed a normally functioning gall bladder without stones. A barium enema was

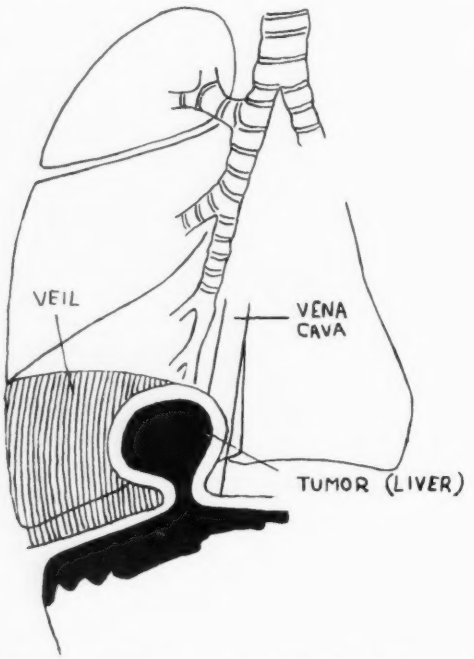


Fig. 3.—Diagrammatic picture of operative findings; note the constricted neck of the herniated and strangulated liver at the diaphragm.

negative. Gastrointestinal x-ray study showed the esophagus, stomach, and duodenum to be free of abnormalities. The spherical tumor mass in the right, lower mediastinum was seen separated from the cardiac portion of the stomach, which ruled out hiatus hernia. Roentgenograms of the pelvis and lumbodorsal spine showed no metastatic lesions. Intravenous pyelography demonstrated a normal urinary tract with no evidence of hypernephroma.

The preoperative radiological diagnosis was a posterior mediastinal tumor, probably benign. Considered were: neurofibroma, dermoid cyst, pericardial cyst, esophageal cyst, tumor of diaphragm, lipoma, pleural tumors, etc. We did not think of herniated liver.

Operation* was performed under intratracheal nitrous oxide-oxygen and curare on Aug. 20, 1946. Incision was made along the course of the seventh rib from the sacrospinalis muscles to the cartilage, and the rib was subperiosteally resected. One inch of the eighth rib was removed anterior to the transverse process. The pleura was opened through the

*Operation by Alfred Goldman.

periosteal bed of the seventh rib. A globular mass bulged (Fig. 3) through the posterior, medial leaf of the diaphragm into the pleural cavity for a distance of 2½ inches. The bulge was very firm and had impressed itself into the diaphragmatic surface of the right lower lobe. The surface of the tumor was thickened by adhesions which were continuous with the inferior pulmonary ligament, the right diaphragmatic crura, and the base of the right lower lobe. The neck of the herniating, pleural mass was constricted about 50 per cent as it traversed the ring of tendinous diaphragm. Posterior and medial to the mass was the deflected inferior vena cava.

There was a well-defined, vestigial, mesentery-like, transparent veil, approximately 5 inches in length, with its superior border attached to the visceral pleura in an arc beginning laterally about 4 inches above the diaphragm at the posterior axillary line and extending medially to attach on a broad base on the diaphragm and continuing around the mass to the inferior vena cava. This veil was incised in order to approach the tumor. When the mass was separated from adherent lung and diaphragm, the bulge was found to be covered by thinned-out tendinous diaphragm and Glisson's capsule. The tendinous, constricting defect in the diaphragm produced a broad, pedicle-like appearance to the herniated, strangulated liver. This tense mass was biopsied, and frozen section showed it to be normal liver.

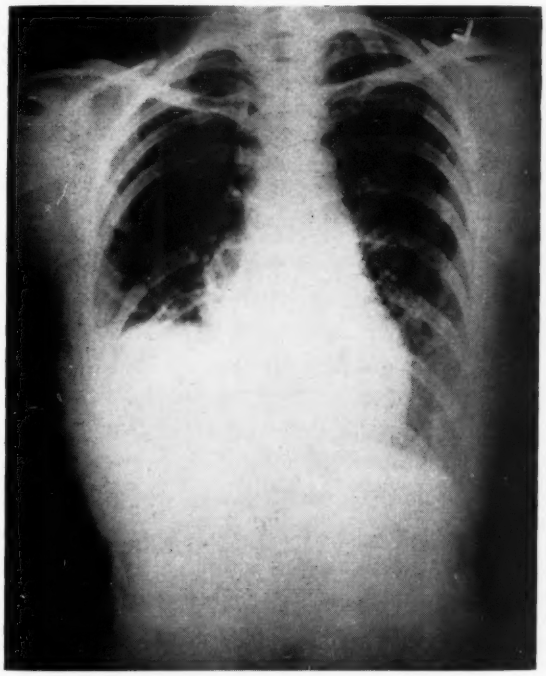

Fig. 4.—Feb. 4, 1947, x-ray view of the chest six months after surgical repair of the strangulated diaphragmatic hernia of the liver. Note the removal of the seventh rib, the high diaphragm due to phrenic nerve crush, and the absence of any tumor mass. The patient has been free from "attacks" since operation.

The tendinous, diaphragmatic constriction was incised in order to reduce the strangulated liver and allow it to drop below the diaphragm. At this time the subdiaphragmatic space was explored and no other pathology was found. A few minutes later, what had been a two-inch sphere had now shrunken to almost the configuration of normal dome of the liver, as though it had been accommodated into the liver itself. The diaphragmatic hernia was repaired with mattress sutures of doubled No. 30 cotton. The phrenic nerve was crushed two inches above the diaphragm. The wound was closed without drainage in layers with interrupted No. 60 cotton sutures throughout. Bronchoscopic aspiration was performed at the end of the operation. During the operation the patient received 500 c.c. of whole blood.

The postoperative course was uneventful; she was ambulatory on the second day, the wound healed per primam, and she did not require thoracentesis. On the eighth postoperative day she was discharged home. Normal activities were resumed in eight weeks. The "door-stop" feeling disappeared at once and there have been no attacks of pain for fourteen months. Fluoroscopy still showed an elevated, fixed diaphragm after fourteen months. The six-month follow-up x-ray view of the chest is shown in Fig. 4.

## COMMENT

Our search of the literature failed to reveal any case of herniation of the liver which was strangulated, presented the symptoms of epigastric pain, nausea, and vomiting, and was operated upon. Lillienthal's case, reported in 1931,[6] was the only case which closely resembled ours. His patient was a female of unstated age, but probably of middle age, who complained of a heaviness in the chest with slight difficulty in breathing and a slight cough, but with no gastro-intestinal complaints. She was known to have had a "tumor" of the chest for sixteen years. The x-ray views showed a large, rounded mass occupying the lower half of the right side of the chest which was thought to be a dermoid cyst of the mediastinum. At operation there was a globular mass covered by the thin, tough membrane of attenuated diaphragm. The right lobe of liver was smaller than normal, like a ball, and had a distinct neck as it bulged into a weak area in the diaphragm. However, strangulation was not mentioned. The diaphragm was paralyzed by crushing the phrenic nerve, and repair consisted of an imbricated closure of the diaphragmatic incision over the mass. This incision had been made in order to explore the subdiaphragmatic space. Reproductions of the pre- and postoperative x-ray pictures showed that the upper limit of the diaphragmatic hernia was one interspace lower following operation. This case differs from ours in not having a constriction at the neck necessitating incision in order to reduce the strangulation. This tumor was larger, and consisted of all of a shrunken right lobe of liver instead of a part of a normal-sized, right lobe as in our case.

In 1908, Elder and Postlethwaite[7] reported a post-mortem examination of a 57-year-old man, in which there was a large tumor in the chest consisting of liver and gall bladder covered by diaphragmatic pleura. The base of the tumor was found resting on liver beneath it and its edges attached to the remaining diaphragm all around it; but no mention was made of strangulation.

In 1910, Keith[8] reported two cases of diaphragmatic hernia discovered at postmortem examination. One was an infant, aged 4 months, and the other a child, but these were not fully described. Their origin was attributed to abnormal liver development within the septum transversum of the embryo.

In 1938, Harrington and Kirklin[2] reviewed 131 cases of diaphragmatic hernia and stated, "In the rare cases of hernia through the right arch of the diaphragm a portion of the liver projects through the breech and is likely mistaken for a neoplasm." Harrington[4] also reported upon 304 patients with diaphragmatic hernia in whom operation was performed. Only one hernia occurred on the right side and contained liver, stomach, duodenum, small bowel, and the head of the pancreas.

In 1943, Bradley and Greiner[5] reported the case of an infant who at the age of 7 weeks was found to have a mass in the right chest. The infant died of pneumonia at the age of 5½ months before the operation could be performed. The autopsy showed the right lobe of the liver and the gall bladder to be in the right chest at the height of the second rib anteriorly, and covered by thin, fibrous membrane which was a defective portion of the diaphragm forming a hernial sac. In addition, there was rudimentary development of the right lung which was offered as evidence that the herniation occurred before birth.

In 1945, Wagner[9] reported a case in which normal liver, the size of a hen's egg, herniated through the right cardiophrenic angle of the diaphragm. At operation the constricting groove was split, the hernia reduced, and phrenicotomy was done. Palpitation was the principal, early symptom, but pain developed later. Neither specific attacks of nausea and vomiting nor presence of strangulation were mentioned.

None of the reports mentioned a congenital veil. However, it was suggested from Haeberlin's[10] case that the veil is an anomaly of the diaphragm. His was a case of a 4-week-old male who died from stenosis of the cardia of the stomach and bronchopneumonia. At post-mortem examination the right pleural cavity was found divided by a membrane extending from the base of the sixth rib forward in an arc to the angle of the inferior vena cava and pericardium where it joined with the diaphragm. The base was transparent but the free margin contained striated muscle and a small nerve and blood vessel.

In the cases just reviewed the symptoms were those of pressure sensations, substernal pain, tachycardia, and dyspnea. The symptomatology in our case was singularly significant and expressive and was offered spontaneously by the patient. The descriptive terms of "squeezing," "ball-like," and "knotty" with "cloudlike spreading" from a central point beneath the xyphoid, "tense obstruction" and "door stop feeling" on bending forward and to the right created a distinct clinical impression of a diaphragmatic hernia. However, when the roentgenograms were reviewed the mass was considered to be a thoracic neoplasm. As in Lillienthal's[6] and Wagner's[9] cases, the findings at surgery came as a complete surprise.

Hedblom[1] stated that among the cases of congenital diaphragmatic hernia there is frequently associated some other anomaly of development such as cleft palate, harelip, patent ductus arteriosus, or foramen ovale. We believe our patient had a patent foramen ovale.

In retrospect, like Lillienthal, we pondered the value of pneumoperitoneum and pneumothorax as diagnostic aids. It is probable that pneumothorax would have been of no value. Pneumoperitoneum might have offered additional information; and should we ever suspect a diaphragmatic hernia of the liver we will try it. We feel it should be tried in every suspected case, because a break in the subdiaphragmatic air mass would probably be roentgenologically demonstrable, thus indicating that the supradiaphragmatic mass is attached to the liver

Since the symptoms presented by our patient were not found in the cases reported it might be questioned that our patient's symptoms were caused by the

herniated liver. We suspect that the absence of these symptoms in the cases previously reported can be ascribed to the absence of strangulation of the liver. Therefore, we feel that the attacks of pain, nausea, and vomiting were related to the strangulation. The absence of any abnormalities in the x-ray examinations of the esophagus, stomach, small and large bowel, biliary tract, and genitourinary tract, together with the disappearance of symptoms following operative reduction of the strangulated liver, lends credence to the idea that the syndrome described was in fact related not so much to the constantly present hernia of the liver but rather to its periodic strangulation.

The conception that this type of hernia is congenital indicates that the herniation of the liver was present since birth, but it is probable that the strangulation first occurred with the onset of the attacks six months before operation. The associated pleural veil, obviously a congenital malformation, as well as the atrial, septal defect in the heart are further evidence for the congenital origin of this hernia of the liver.

## SUMMARY AND CONCLUSIONS

A case of congenital, strangulated, diaphragmatic hernia of the liver with surgical cure is reported. This case included a unique symptomatology of attacks of nausea, vomiting, and epigastric pain described as "cloud like" with radiation to both lower, lateral thoracic areas. A "doorstop" feeling on bending forward was a prominent feature of the symptomatology. These symptoms probably have a causal relationship to the strangulation of the herniated liver; and with the surgical reduction of the hernia the patient experienced a complete and lasting cure. When a mass is radiologically demonstrated in the pericardiodiaphragmatic sulcus, herniation of the liver should be considered as well as the more common lesions. If abdominal symptoms of the type described herein are present, it is reasonable to suspect strangulation of the herniated liver, and exploratory thoracotomy should be advised.

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# LIPOMA OF THE THENAR

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THE distribution of adipose tissue is widespread, yet in some locations neoplasms composed of adipose tissue alone, lipomas, rarely occur. One of these sites is the palm of the hand. Not counting lipomas arising in tendon sheaths of fingers, only about ten lipomas of the palm have been reported to date (Straus,[1] Valdoni,[2] Pollosson, Francon, and Pizzera,[3] Mason,[4] and Bunnell[5]). Few of these growths were recognized as lipomas before operative removal. The case herein reported is believed to be the first lipoma of the palm recorded in a Negro.

## REPORT OF CASE

G. R., a 40-year-old Negro woman, was admitted to the University of Oklahoma Hospitals, March 25, 1947, with the complaint of a painless swelling of the left hand, first noted in February, 1944. The swelling was located between the thumb and the index finger and increased gradually to its present size causing progressive limitation of opposition between the thumb and fingers.

Fig. 1.—Roentgenogram of the left hand disclosing a globular soft tissue mass between the first and second metacarpal bones with a lesser density than the surrounding soft tissue, thought to be a lipoma.

At the time of admission the patient appeared to be in good health. The only positive finding was a ballotable soft mass between the left thumb and index finger, limited to the thenar area and elevated 2.5 cm. above the palmar and 1.5 cm. over the dorsal surfaces. The skin over the mass was smooth, somewhat stretched, movable, and not tender or painful. The mass did not transmit light. The thumb and index finger could not be apposed. Roentgenographic examination disclosed a globular soft tissue mass between the first and second metacarpal bones with a lesser density than the surrounding soft tissues. The mass was thought to be a lipoma (Fig. 1).

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Under regional nerve block anesthesia with procaine (2 per cent) and after application of a pneumatic tourniquet over the arm, an incision 9 cm. long was made along the thenar crease. The skin with the fascia was reflected radially. The thenar muscles were incised parallel to their fibers exposing a globular, encapsulated, yellow mass, apparently composed of adipose tissue. After freeing of the palmar portion and separation from its attachment to the tendon sheath of the flexor pollicis longus, pressure on the dorsal extension of the mass delivered it into the wound. Following removal of the tourniquet, bleeding was slight. After hemostasis the wound was closed in layers and a pressure bandage applied. Healing of the wound was uneventful. When the patient was last seen, Aug. 31, 1947, the thenar areas were symmetrical and there was no impairment of the function of the thumb and fingers.

Fig. 2.—Lipoma of the thenar; the growth is composed entirely of various-sized lobules of adipose tissue.

The specimen consisted of a slightly lobulated globular mass of adipose tissue 7 by 5 by 3 cm. and weighing 50 Gm. (Fig. 2). A delicate transparent capsule surrounded the mass. The rounded elevations on the surface measured 1 to 4 cm. in diameter. The cut surfaces had the appearance of straw yellow adipose tissue. Microscopic preparations from various parts of the mass stained with hematoxylin and eosin disclosed various-sized lobules of adipose tissue cells with delicate connective tissue septa containing blood vessels. A capsulelike condensation of the fibrous connective tissue could be made out at the periphery of the growth.

## SUMMARY

A lipoma of the thenar in a 40-year-old Negro woman is reported. This apparently is the eleventh lipoma of the palm and the first such growth recorded in a Negro.

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# THE DILUTE PENTOTHAL DRIP INFUSION

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WE AND our associates have been administering pentothal sodium in very dilute solution as a drip infusion during the past two years in over 5000 cases. It has proved to be so widely and variously useful that we believe it deserves greater popularity.

Solkow and Clements[1] in 1942 were the first to report the drip infusion of 1:200 and 1:100 solutions of pentothal for complete intravenous anesthesia. Lenowitz, Lipson, and Stevens,[2] in 1944, described the infusion of 1:1000 and 1:500 Pentothal sodium for sedation and narcosis. Their excellent experience with high dilutions in 512 patients undergoing surgery under spinal, regional, and local anesthesia provided a physically easier and clinically safer method for the greater application of the virtues of the more concentrated solutions of pentothal sodium recommended as an adjuvant to regional anesthesia by earlier authors.[3, 4, 5] Stevens[6] used various dilutions of Pentothal sodium, 1:250 for complete anesthesia, 1:500 and 1:1000 for sedation or hypnosis in good-risk patients, and basal anesthesia in poor risks. He confirmed the facts of safety, sterility, and the persistence of potency of these solutions in bulk kept for five days or more. The "dilute pentothal drip" was then such an innovation that Adams,[7] in his extensive review of the literature published in 1944, did not refer to the use of such a dilution.

## TECHNIQUE

The standard solution always on hand is 1:1000. The choice of the concentration of Pentothal sodium, varying from 1:2000 to 1:250, must be guided by several factors: (a) the depth of sedation, narcosis, or anesthesia desired, (b) the "anesthetic resistance" and the effect of premedication, (c) the total volume of fluid considered optimum, (d) the size of the needle and the desirable rate of flow of the infusion. As a rule, the needle is 20 gauge, the concentration is 1:1000, and the total volume infused for sedation is 200 to 400 c.c., for basal anesthesia 300 to 1000 c.c.

For a short complete anesthesia with pentothal we still prefer the intermittent injection of 2.5 per cent. For complete anesthesia with pentothal for a long period of time, when the intermittent method might be inconvenient and tiresome, we now prefer the drip method, with 1:250 to 1:2000 pentothal, to the intermittent injection of the 2.5 per cent concentration after the first hour when the patient has settled down to requiring only small amounts per hour. The earlier experience of the senior author with the use of Pentothal sodium in special cases[8] and for prolonged surgery[9] enables us to appreciate more clearly the convenience, continuity, and careful control provided by the "dilute pentothal drip."

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Pentothal is dissolved usually in five per cent glucose in saline solution. For the eclamptic, cardiac, or other disease states in which saline solution is contraindicated, the solvent is 5 to 10 per cent glucose in distilled water.

### INDICATIONS AND ADVANTAGES

1. *As Sedative or Hypnotic in Spinal Anesthesia.*—The most frequent indication for 1:1000 Pentothal sodium solution is sedation and light hypnosis during spinal anesthesia. Whereas we and practically all of our surgeons prefer and use spinal anesthesia in the great majority of operations below the diaphragm, most patients desire to be asleep during the operation. Pentothal, 50 to 200 c.c. of 1:1000 solution produces a dozing or lightly sleeping patient within 5 to 15 minutes, depending on the preoperative effect of the usual premedication. Drowsiness by properly timed and chosen premedication is frequently not attained because of special circumstances, for example, a delay in the operating room schedules, insufficient time before emergency operation, individual differences in response, personal preferences of a surgeon, etc. In the past, intravenous morphine sulfate, with or without scopolamine hydrobromide, was used to correct these inadequacies in premedication. With 1:1000 Pentothal sodium one can obtain a calm, quiet, dozing patient more precisely and reliably. After the loss of the eyelash reflex, the rate of flow is slowed to maintain sleep in deep first stage anesthesia. The patient avoids unpleasant memories and is indifferent to the discomforts of the operating table, for example, the pressure of the shoulder guards in deep Trendelenburg position, and the prolonged immobility of arms and head during lengthy operations. The accurate control of certain sleep has enabled us to increase our service to the surgeons by using spinal anesthesia in a greater percentage of cases. The private patient who used to refuse spinal anesthesia now accepts it willingly, if promised a pleasant induction of sleep. The "dilute pentothal drip" enables one to produce sleep, if necessary, for lumbar puncture without the assistance of another anesthetist and without fear of the respiratory obstruction and depression possible with 2.5 per cent Pentothal sodium administered to a patient in the lateral position for lumbar puncture. The surgeon who, for one reason or another, used to prefer his patient to be asleep during operation is pleased to secure the incomparable advantages of spinal anesthesia without the disadvantages of inhalation anesthesia. The infusion of pentothal has the following advantages over inhalation anesthesia as a supplement to spinal anesthesia: (1) it avoids the mask, which frightens some patients, gives others the erroneous impression that the spinal has failed, and creates dead space retention of carbon dioxide with its attendant interference with the "quiet abdomen" of spinal anesthesia by deep breathing; (2) it is practically never associated with nausea or vomiting during induction into or recovery from sleep in contrast to the inhalational agents; (3) it is more economical; (4) it does not demand an anesthetic machine, thereby freeing the latter for other cases.

It is the agent par excellence to supplement spinal anesthesia which is unavoidably complicated, at times, by painful traction reflexes mediated by vagal and phrenic pathways. Pulling on the gall bladder, liver, stomach, esophagus,

or diaphragm is often accompanied by retching or vomiting, making the patient miserable and the surgery more difficult, if not impossible. The situation can be remedied promptly and reliably by 100 to 300 c.c. of 1:1000 pentothal; the patient and the surgical field become quiet, often before the patient goes to sleep.

The dilute pentothal infusion lends itself to avoiding overdosage with general anesthesia when the latter is utilized as a supplement to spinal or regional analgesia. It is the rule to see the patient reacting vigorously in the operating room even after three hours of sleep with very dilute pentothal solutions.

2. *As a Basal Anesthetic.*—The "dilute drip" is a more precise method of producing a minimal level of general anesthesia with or without supplementary agents. In this way one can more safely give the small, fractionally administered doses of 0.1 to 0.3 Gm. of Pentothal sodium needed, for example, in borderline shock or during the unpleasant moments of cesarean section or pinning of the hip under local anesthesia.

3. *As an "Anti-thyrotoxic" Agent.*—All of our hyperthyroid patients[10] except "burnt out" ones (who are very susceptible to any depressant agent) are carried through operation with basal anesthesia produced by an infusion of 1:1000 Pentothal sodium started either in the operating room or, occasionally, in the patient's room to conceal the impending operation. Unlike tribromethanol, dilute pentothal does not produce respiratory or circulatory depression; better than tribromethanol, it antidotes thyrotoxic effects on metabolism and circulation. The value of Pentothal sodium for the antagonism of thyroid toxicity during operation may be continued after operation when a thyroid storm is considered to be a likely sequel. Hudon's experience in 600 cases[11] with Pentothal in surgery for hyperthyroidism has shown its "anti-thyrotoxic" value. With pentothal basal anesthesia a postoperative thyroid storm has never occurred in our experience. In the few cases of severe hyperthyroidism which were not, for reasons beyond our control, anesthetized with Pentothal sodium, we have secured, with a dilute pentothal infusion, excellent control of thyroid toxicity after operation. The postoperative sleep, accurately and quickly regulated at a light level with active throat reflexes, is better obtained with 1:1000 pentothal than with the traditional but improperly indicated postoperative morphine. Hudon, using 2.5 per cent pentothal as the complete and sole anesthetic agent, encountered respiratory depression in several cases. Dilute pentothal has made it easy to avoid this undesirable state.

4. *As Depressant of Excessive Sympathetic Nervous System Activity.*—The apprehension and excited sensitivity of some patients during regional anesthesia are, at times, engendered by an excessive use of, or reaction to, the epinephrine injected with the anesthetic drug. Barbiturates are excellent antagonists for generalized sympathetic nervous overactivity. Pentothal is one of the most controllable of all barbiturates, especially in a very dilute solution. Therefore, we regard the "dilute pentothal drip" as the indicated means of solving an unpleasant situation created by a fearful and anxious patient complaining of every touch, restless, jittery, and twitching during an otherwise satisfactory regional block. Another indication for the use of the special ability of pentothal to depress excessive sympathetic stimulation is to induce general

anesthesia in the patient whose sympathetic nervous activity is at a peak as a result of painful surgery with an inadequate cocaine surface anesthesia and ephedrine stimulation in the presence of an unsuccessful or waning spinal anesthesia. Under these and similar circumstances cyclopropane might be dangerous because of cardiac hyperirritability and nitrous oxide or ethylene too weak to overcome without severe anoxia the greatly increased metabolic level.

The "dilute pentothal drip" is the safest and most practicable means of combating the transient hypertension and severe headache occasionally seen as an excessive response to the vasopressor drugs, neosynephrine or ephedrine, especially with posterior pituitary extract during spinal anesthesia.

5. *In Cardiac Patients.*—The "dilute pentothal drip" is a precise and very convenient method for the induction of general anesthesia in cardiac patients when premedication has failed to produce the needed degree of sedation for safe induction with the inhalational agents. The dilute pentothal drip is without effect on the heart and peripheral circulatory mechanism, and avoids the disadvantages of cyclopropane effects on cardiac irritability, of anoxia with nitrous oxide or ethylene, and of prolonged excitement with ether. For special protection against undue cardiac irritability,[12, 13] procaine hydrochloride may be added to the pentothal infusion, as suggested by Kraft.[14] Thus, procaine 1:1000 and pentothal 1:1000 may be mixed and administered in the same solution. Precipitation does not take place between the two drugs in 1:1000 concentrations. The "dilute pentothal drip" is particularly useful as a vehicle for intravenous procaine. The safety of intravenous procaine, primarily dependent on high dilution and slow administration, is enhanced by the pentothal hypnosis. The pentothal may be discontinued after induction in favor of ether, the agent of choice for maintenance of anesthesia in cardiac patients, or the pentothal may be neatly combined with safe concentrations of nitrous oxide or ethylene and oxygen, with curare if necessary for relaxation. Curare solutions may be injected directly into the tubing containing dilute pentothal with negligible precipitation and without any noticeable decrease of curare effect.

6. *As a Means of Administering Pentothal Outside of the Operating Room.*—The acknowledged superiority of pentothal for the control of convulsions has been safely and readily adapted, by means of the dilute infusion, to five cases of eclampsia before, during, and after cesarean section. Similarly, we have easily controlled convulsions arising from cerebral damage by anoxia as a result of circulatory failure during spinal anesthesia.

The "dilute pentothal drip" is the only safe and practicable way of administering pentothal for a prolonged period of time in the patient's room. By alternating two connected infusion solutions, one of dilute pentothal and the other without pentothal, sleep or sedation has been nicely continued for many hours on the ward. Of course this form of hypnosis or sedation is utilized only for serious or special conditions, when the patient is under continuous, intelligent, and instructed medical and nursing supervision.

### CONTRAINDICATIONS AND PRECAUTIONS

Dilute pentothal is not an analgesic; it is not an efficient substitute for poor regional or spinal analgesia. It should not be used to stop nausea or vom-

iting resulting from a fall of blood pressure; for this the choice is intravenous ephedrine or restoration of blood volume, depending on the cause. Pentothal is not employed when hypoxia of any origin is the reason for a complication. Even a small volume of 1:1000 Pentothal sodium has caused apnea during high spinal anesthesia in a good-risk patient. The high dilution does not eliminate the precautions associated with the proper use of intravenous anesthesia.[15]

Dilute pentothal for basal anesthesia requires the same preoperative attention to adequate premedication with atropine as has been found desirable with 2.5 per cent pentothal if one is to avoid excessive bronchial secretion, laryngospasm, and hiccups.

The first postoperative dose of morphine should be one-third to one-half less than usual for the patient who has received a dilute pentothal solution. Even the administration of 0.3 to 0.5 Gm. Pentothal sodium during one to two hours leaves a postoperative sedative effect as shown by an increased susceptibility to respiratory depression by morphine and a decreased tendency to vomit.

## SUMMARY AND CONCLUSIONS

The "dilute pentothal drip" infusion is a handy, adaptable, precise, and economical method of utilizing the special qualities of Pentothal sodium before, during, and after operation. The valuable characteristics which are made more evidently and widely useful by the highly dilute solution of Pentothal sodium are (1) sedative and hypnotic, (2) basal anesthetic, (3) anticonvulsant, (4) antiemetic, (5) antithyrotoxic, and (6) depressant of excessive sympathetic stimulation.

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# A NEW LAMINECTOMY RETRACTOR

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A LAMINECTOMY retractor, to be satisfactory, must be constructed so that it can be easily and quickly inserted and stable enough to resist the strong pull of the paravertebral muscles when they have been displaced laterally. A retractor has been devised which meets these requirements. The simplicity of its design is the result of improvement or elimination of several cumbersome features of earlier models which we made.

The instrument consists essentially of two sets of parts: the retractor blades and a rectangular frame to hold and to spread them. The frame (Fig. 1) is made of two parallel square brass bars; one of these has two round solid rods screwed into it and the other is fitted with two tubes which serve for reception of the round rods. The rods fit into the tubes just loosely enough to permit easy extension of the frame. The tubes are tightly fitted through holes in one of the square bars and soldered in place.

The locking device (Fig. 1) is made of two short pieces of slightly curved spring steel. Drilled through each spring is a hole with a diameter slightly larger than that of the solid rod, the spring being attached with two screws on the outside of the bar bearing the tubes. This lock allows the rods to be pulled through as the frame is spread open but rigidly resists closure of the frame unless pressure is applied with the fingers on the free ends of the springs. This lock has proved to be efficient and has the advantage of being easily released.

There are three sets of retractor blades differing only in length. The one to be used is determined by the thickness of the tissues to be retracted. The individual retractor blade is curved to fit snugly against the paravertebral muscles and skin (Fig. 2). The distal end is bent at right angles and serrated with the teeth beveled to a sharp edge laterally to anchor the blade against the tissues to be retracted. Each retractor blade has a thick, tapered, headed pin passed through it and soldered for increased rigidity. Each of the bars of the retractor frame has five holes reamed with a No. 6 taper bit. This arrangement allows the individual blades to be easily placed directly opposite the vertebral laminas or intervertebral ligaments which are to be approached surgically. The frame is then placed over the blades and the tapered pins are guided into the closest holes. Slight pressure on the frame then locks the blades in place. One of the greatest advantages of this instrument is its adaptability for insertion of the blades where retraction is most needed.

The dimensions and shape of the components of the retractor are accurately indicated in Fig. 1. Our instrument was made of brass because of the ease with

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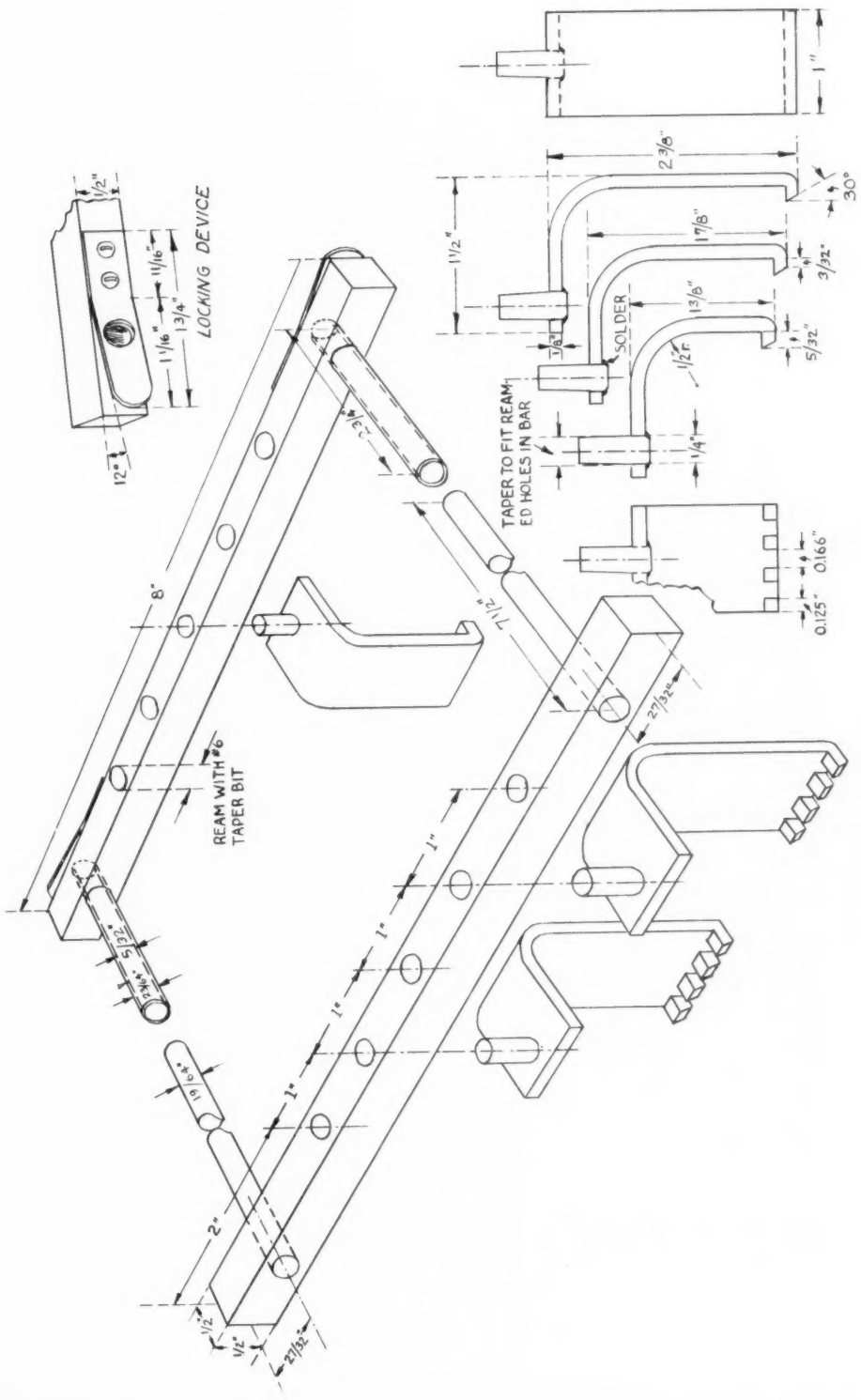


Fig. 1.—Details of retractor frame, blades, and locking device.

which that metal can be machined. A skilled machinist could make a lighter and stronger one of stainless steel.

The retractor functions equally well for unilateral or bilateral laminectomy. If a hemilaminectomy is to be performed, only one blade is placed on the opposite side. The lumbodorsal fascia of that side is separated from its attachment by an incision just long enough to slip a single blade past it to occupy a position comparable to that of blades on the side of the operator. Thus, the instrument is anchored as firmly as if laminas were being exposed bilaterally and the tissues of the opposite side are subjected to a minimum of trauma. On the side of the operation retractor blades are placed directly opposite the laminas or ligamenta flava in question; this assures maximal retraction at the most

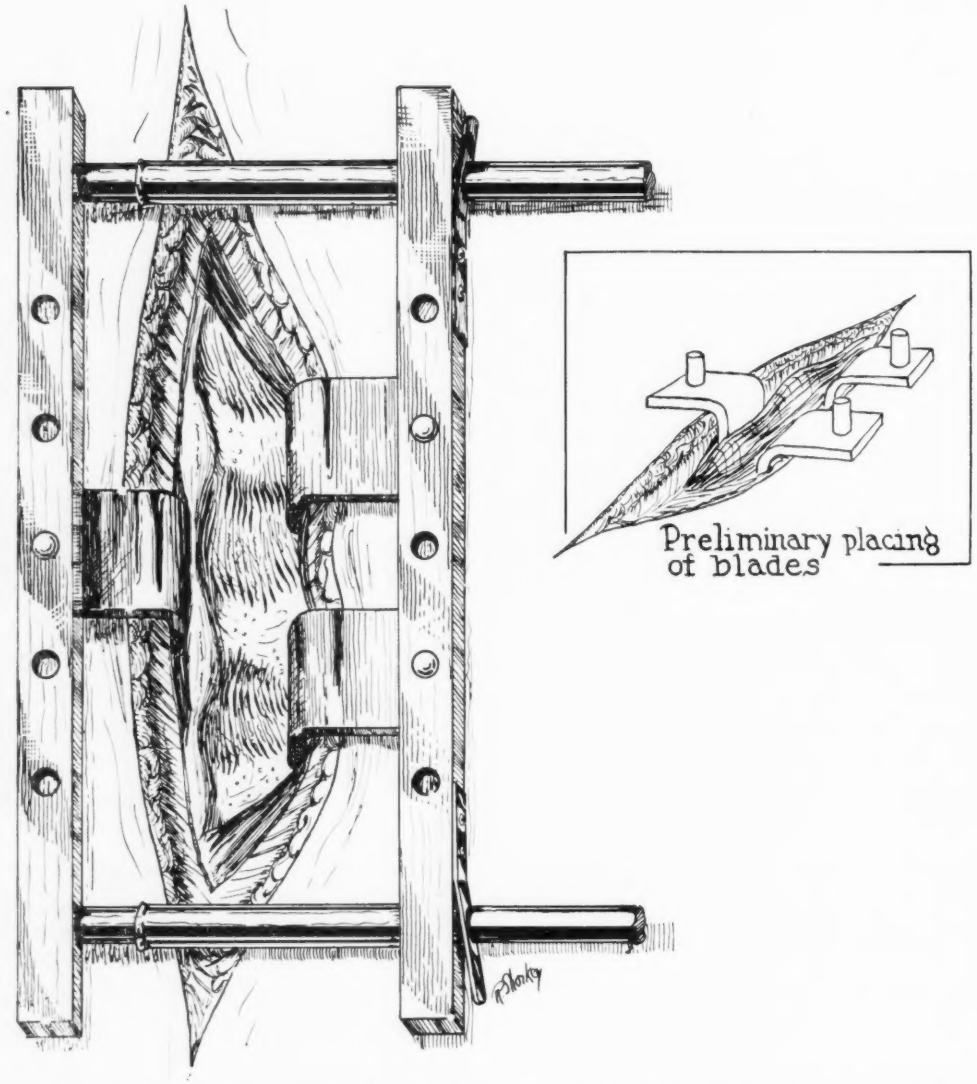


Fig. 2.—Retractor in place for a hemilaminectomy. Inset shows blades in position before the retractor frame is placed over them.

desired points. A blade of such length that it will pass laterally along the transverse process and at the same time allow the frame of the retractor to fit firmly against the skin is used. Retractor frames shaped to fit more accurately the lordotic curve of the lumbar and cervical regions and the kyphotic curve of the thoracic region have been designed. The position of the blades at right angles to the long axis of the muscles to be held aside provides satisfactory retraction with separation of the lumbodorsal fascia and adjacent muscles from their attachments for a relatively short distance, so that operative trauma is further minimized. The fact that one or several blades may be used on each side also permits exposure of the area without undue disturbance of overlying tissues. The number of blades used on one side (one to five) is determined by the size of the area to be exposed.

This instrument has proved to function satisfactorily. The simplicity of its design and action assures a minimum of difficulty in its use.

# Case Reports

## APOPLEXY OF THE GALL BLADDER

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THE purpose of this communication is to report an extremely rare condition, in which there was a large hemorrhage into the noncalculous gall bladder of a patient with essential hypertension. A search of the literature has failed to disclose an identical case.

"Hemocholecyst" is the term applied by Fiessinger[1] to massive, nontraumatic gall bladder hemorrhage. We have employed the term "apoplexy of the gall bladder" in the case herewith presented as there was hypertension and absence of gallstones.

It is thought likely that slight bleeding may occur frequently in diseased gall bladders. Hudson and Johnson[2] found blood in the stools in 13 per cent of 100 consecutive cases of cholelithiasis in which operation was required and in 8 per cent of 100 cases of cholecystitis without cholelithiasis. A massive hemorrhage, in the belief of most early writers, is due to infection. However, a large hemorrhage may also be due to trauma,[3, 4, 5] a tumor, rupture of an aneurysm of the cystic artery,[6] or some other intrinsic pathologic changes in the blood vessels.[7] Hudson and Johnson found that sclerotic changes were present in their 4 cases and considered these significant, with mechanical irritation from stones being of secondary importance. Fiessinger stated that "the causes of the hemorrhage are processes, either toxic or irritative, which are capable of producing superficial or deep vascular ruptures."

A large hemorrhage may remain localized to the gall bladder, it may diffuse through the bile ducts into the bowel causing melena or hematemesis, or it may produce sufficient pressure within the gall bladder to rupture the viscus and permit free bleeding into the peritoneal cavity.

If traumatic cases are excluded, massive hemorrhage from the gall bladder is almost always associated with cholelithiasis. On reviewing the literature, 28 such cases were found to have been reported. However, massive hemorrhage from a noncalculous gall bladder is very rare. In addition to the case herewith presented, only two other cases have been reported, one by Schnyder[8] concerning a man aged 72 years, and one by Fiessinger concerning a boy aged 4½ years.

Hypertension has been noted in only one other case of massive hemorrhage, that of Hudson and Johnson, the blood pressure being 186/104, but in their case cholelithiasis was present.

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## REPORT OF CASE

Mrs. A. M., a 46-year-old housewife, was admitted to Evanston Hospital in January, 1946, for observation and treatment of essential hypertension of two years' duration. The systolic blood pressure slowly dropped from 280 to 170, with the diastolic pressure remaining around 120. No symptoms of gall bladder disease were noted.

The second admission was on Oct. 3, 1946. She had awakened at 3 o'clock that morning feeling as well as usual, but one hour later had reawakened with a sudden excruciating pain in the epigastrium. A physician gave her ⅓ gr. of Pantopon, with only slight relief, and she was transferred to the hospital. The temperature was 98° F., the pulse 106, and the respiratory rate 22. The white blood cell count was 21,500, and the urine showed 1 plus albumin and a few white and red cells. The left heart border was 11 cm. from the midsternal line, and the blood pressure was 280/160. Examination of the abdomen revealed tenderness and almost boardlike rigidity in the right upper quadrant and to a slightly lesser extent in the left upper and right lower quadrants. The preoperative diagnosis was perforated peptic ulcer. Operation revealed an enormously distended, turgid, almost blue-black gall bladder. There was also some ecchymosis under the peritoneum surrounding the common bile duct and adjacent structures, and a small amount of blood-tinged fluid was found in the peritoneal cavity. Cholecystectomy was performed. The patient was discharged from the hospital eight days later, after an uneventful postoperative course.

On gross examination in the pathology laboratory, the lumen of the gall bladder was observed to be filled with blood, and no calculi were found. The mucosa was markedly hyperemic and showed marked cholesterosis. Small hemorrhages were scattered throughout the wall, but in an area 3.5 by 2 cm. near the base of the fundus the wall was thickened, and there was gross hemorrhage with a mucosal tear measuring 1.2 by 1.5 cm. No aneurysm of the cystic artery was demonstrated, and no evidence of infarction was seen. Microscopically, congestion and hemorrhage into the wall and the lumen were obvious. Scattered areas of chronic cellular infiltration and some fibrosis of the wall were noted.

On Nov. 20, 1946, forty days after the patient's last discharge from the hospital, she was readmitted because of severe frontal and occipital headaches, diplopia, and palpitation. The blood pressure on admission was 238/168 and rose to 300/180 in spite of absolute bed rest and the administration of bromides and Nitranitol. On December 12, she became confused and finally stuporous and died on December 25, five weeks after admission and in the fourth year of the essential hypertension. The most significant findings on post-mortem examination were generalized arteriosclerosis including the brain, arteriosclerotic kidneys with arteriolosclerosis and small multiple infarcts in the brain.

Comparison of the autopsy findings in the small caliber vessels of the kidneys, myocardium, and brain with those in the vessels of the surgically removed gall bladder were of interest. In the gall bladder the prearteriolar and arteriolar changes were those of collagenous intimal thickening, with many small areas of hyalin in the subintimal region. No thrombonecrosis was seen. Most vessels so involved had lumina which were stenosed almost to the point of occlusion. Larger vessels were not as stenotic, although the internal elastic proliferation and other arteriosclerotic effects were prominent. Changes in the renal, myocardial, and cerebral vessels of small caliber showed lesions corresponding to those described in the gall bladder except that hyalinization was more pronounced. Tissues from the other organs showed a comparable effect and were compatible with a diagnosis of essential hypertension.

## CONCLUSION

A case of essential hypertension is reported in which there was a massive hemorrhage into a noncalculous gall bladder.

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# PERFORATION OF THE SIGMOID FOLLOWING ENEMA

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PERFORATION of the colon has been reported in the literature many times and has received detailed attention in the textbooks of surgery. Among the etiologic agents and factors indited in this pathology are compressed air,[1-5] enema nozzles, foreign bodies inserted into the rectum or taken by mouth, proctoscopes, sigmoidoscopes, bullets and other projectile objects, intestinal obstruction usually in the distal part of the large bowel where the peristaltic movements may increase the intraluminal gas pressure to such an extent as to cause a rupture, and blows and other injuries to the abdominal wall. Other conditions which have been mentioned include diverticula, polyps, malignant tumors, and inflammatory lesions such as typhoid fever, amoebiasis, perisigmoiditis, and ulcerative colitis.

Intestinal perforation following the administration of an enema has on the other hand appeared in the literature but rarely. In the few times that such reports have been made it was usually the enema tip or nozzle plus the forceful insertion of the same that has been at the basis of the rupture. Rayner[6] emphasized this, as did Menegaux.[7]

In the only case comparable to the one herein reported that we have been able to find, Hawkes[8] discussed the instance of a patient who administered an enema to himself by attaching a soft rubber tube to the faucet of a bathtub, inserted the tube into his rectum, and turned on the water. The amount of water to be given was judged by the man's intestinal sensations. The practice was repeated without harm many times until one morning he gave himself a double administration followed by a perforation of the sigmoid colon.

He was operated upon six hours after the rupture had occurred. The perforation was repaired and a proximal cecostomy performed. The patient was discharged in good condition after forty-six hospital days with a moderate amount of drainage from the incisional wound and from the cecostomy.

In the case that follows the perforating force apparently was not produced, as in this instance, by direct flow of the enema fluid but by postural increase in intraabdominal pressure.

## REPORT OF CASE

R. M., a 52-year-old white man, born in Switzerland and a baker by profession, was admitted to the hospital at 7 P.M., May 11, 1947. He was obviously in great distress and complained of severe, generalized lower abdominal pain. About five hours prior to admission he had given himself an enema consisting of about two quarts of soapy water from the usual type enema can attached by a rubber tube to a hard rubber nozzle. (The patient stated he had been in the habit of giving himself enemas for many years for reasons not immediately apparent, save to "clean himself out."

Following the removal of the enema tip the patient decided to retain the fluid for a while. He sat on the edge of the bathtub and leaned forward. A few moments after this he

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was seized with lancinating pain in the left lower quadrant and was not able to pass any of the enema fluid. The patient went to bed and when the pain did not decrease in severity he called a physician about three hours after the episode.

Past history and systemic review were essentially negative save for an abdominal operation in another hospital some fourteen years previously following a knife wound in the upper part of the abdomen. Convalescence was apparently uncomplicated. There was no history of constipation or diarrhea, weight loss, black or bloody stools.

Physical examination revealed an obese, white man complaining of severe abdominal pain. The face was flushed and warm and there was profuse diaphoresis. The temperature was 100° F., pulse 110, respirations 26, and blood pressure 120/70. The heart and lungs were clinically normal.

The abdomen was ovoid in appearance and presented for inspection a well-healed upper midline scar. Rigidity and distention were prominent and generalized. The percussion note was tympanitic throughout. Both lower quadrants were tender to palpation, the left being somewhat greater than the right. Rebound tenderness was marked over the lower abdomen. Auscultation revealed a complete absence of bowel sounds. There was no tenderness over the costovertebral angles.

Neurologically and skeletally the patient presented no abnormalities.

Laboratory data showed a white blood count of 7,100 with 88 per cent polymorphonuclear leucocytes, 12 of which were early forms, and 12 per cent mononuclear cells. Red blood count was 4,100,000 with 93 per cent hemoglobin (Sahli). Urine was straw colored and clear. Specific gravity was 1.020, and it was found negative for sugar, protein and inflammatory cells.

A Miller-Abbott tube was inserted and the patient brought to the operating room at 9 P.M., seven hours following onset. Anesthesia was spinal (Pontocaine).

The abdomen was opened through an ample lower left rectus muscle-splitting incision. Immediately upon incising the peritoneum there was a gush of fecal-smelling fluid into the wound. Fluid was dark and turbid and contained many undigested food particles, the operators being able to distinguish small pieces of mushroom. (The patient had eaten a steak with mushroom sauce the night before.)

As much of the fluid as possible was removed by suction. The small bowel was greatly distended and injected throughout.

The pelvis was explored and after considerable mechanical difficulty, because of the distention and the patient's obesity, a perforation on the free or antimesenteric border of the sigmoid colon was found. It measured about 3 cm. in length and was located just above the peritoneal reflection on the posterior border of the bladder on the pelvic brim. The surrounding serosa was purplish black in color and mottled in appearance for a distance of about 10 cm. from the circumference of the rupture. (It looked like a powder-burn around a wound from a bullet that has been fired from close range.) There was no evidence of a diverticulum or other pathologic lesion at this site. Further exploration of the abdominal contents was not attempted.

The perforation was closed transversely with one layer of continuous 0 plain catgut suture on an atraumatic needle, and a second layer of interrupted silk sutures. A large cigarette drain was placed in the cul-de-sac and brought out through the lower angle of the incision. The abdomen was then closed in layers using chromic catgut for the peritoneum and fascia, and silk for the skin.

After the abdomen was re-draped, a McBurney incision was made in the right lower quadrant, the cecum identified, incised, and a large urethral catheter placed into it and held in position with two layers of purse-string sutures of plain catgut.

Immediately postoperatively the patient's condition appeared to be fair.

Wangensteen suction was applied to the Miller-Abbott tube and to the cecostomy tube, the patient receiving nothing by mouth except a little cracked ice for the first seventy-two hours. He received daily infusions of glucose, saline solution, and protein hydrolysates plus vitamins C and B complex. Sodium sulfadiazine in therapeutic doses was administered

intravenously, and the patient was given 50,000 units of penicillin and 200 mg. of streptomycin every three hours.

The patient's temperature rose to 103° F. on the first postoperative day and then gradually fell by lysis to normal eleven days following surgery.

Blood, 500 c.c., was given on the second postoperative day without reaction. Sulfadiazine was discontinued after four days, penicillin and streptomycin after ten.

Distention disappeared on the third day. The patient had three small bowel movements on the fourth and was out of bed on the sixth day. The Miller-Abbott tube had been removed the day previously and the catheter sloughed out of the cecum one week after the operation.

Recovery from then on was uncomplicated. Drainage from the incision was minimal and finally stopped altogether in two weeks, about the same time that the cecostomy closed over and began to heal spontaneously.

The patient was discharged asymptomatic on the twenty-first hospital day.

## COMMENT

This case illustrates many of the features that have been delineated in the literature in the past concerning sudden perforation of the large intestine. So far as can be determined, however, it is the first instance recorded of a perforation following an enema after the enema apparatus had been removed and in which the patient had retained the fluid. Somewhat noteworthy too was the rapid convalescence following an episode of such gravity.

Colonic ruptures are always pernicious because of the highly pathologic bacterial flora which gain access to the free peritoneal cavity. Mortality in several series of rupture has varied between 50 and 75 per cent, most of these following pneumonic perforation of the colon.

An enema of course gaining access to the free abdominal cavity offers a vehicle for wider dissemination of fecal material and the prognosis must subsequently be more guarded.

In the series of operative cases cited by Hays,[9] the site of pneumonic rupture was the sigmoid in ten instances, the splenic flexure in one, the hepatic flexure in one, and the rectum in two. The sigmoid is most involved doubtless because of its anatomic position. The rectum is a relatively fixed organ and well protected, while the sigmoid is the first freely movable part of the large bowel that is encountered in a distal to proximal direction. Then too the sharp curve it describes is probably contributory to making it the most common site of traumatic rupture in which retrograde force is the etiologic factor. Andrews[10] has shown experimentally that it took only seven to twelve and one-half pounds of pressure to rupture a piece of human intestine.

From a grossly pathologic point of view the powder-burn appearance of the serosa immediately adjacent to the perforation is characteristic and offers a ready means of discovering the site of lesion, especially in patients on whom surgery is mechanically difficult—who are obese and who present evidences of marked distention as did the one just reported.

The history is usually readily obtained and characteristic. Pain is the first symptom complained of in a majority of cases and usually comes on suddenly, although in a few instances it has not occurred for an hour or two following the exciting force. The pain is continuous in character and severe. The face is contorted and anxious. The abdomen is tender, rigid, and exhibits rebound phe-

nomena. Auscultation reveals absence of peristalsis after the lapse of a few hours. The temperature at first is usually normal, subnormal, or only mildly elevated. The white blood count commonly rises to 15,000 to 18,000, although in the current instance it remained normal, showing a shift to the left in the differential calculation.

In Hawkes' case and in the present one, the surgical approach was identical. In the current one, however, the period of convalescence and time for healing were just about halved. This undoubtedly follows from the newer knowledge of nutrition, protein balance, the use of vitamin C and of the chemotherapeutic drugs. The question of drainage remains in abeyance. In this case no deleterious effects were noted.

## SUMMARY

1. A case of traumatic perforation of an apparently nonpathologic sigmoid following self-administration of an enema has been presented. The enema fluid was retained and rupture followed sudden increase in intra-abdominal pressure occasioned by the patient's bending over.

2. The signs and symptoms following traumatic colonic perforation have been outlined and the salient anatomic, physiologic, and pathologic factors enumerated.

3. The literature has been reviewed.

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# Editorial

## Why Treat Gastric Ulcers Medically?

IT WOULD seem that sufficient evidence has now been accumulated to justify the conclusion that gastric ulcer should always be treated surgically unless the individual's physical condition makes this inadvisable. It is a well-known fact that the medical profession is slow to discard any well-established therapeutic procedure so it is not surprising to note that many still cling to the belief that, initially at least, gastric ulcer is a medical problem. The evidence in favor of surgery is so overwhelming that it would seem justifiable to present again the subject for the benefit of those who still favor conservatism. The gradual realization of two indisputable facts is responsible for the changed attitude toward the therapy of gastric ulcer.

First, there is at present no known method or methods by which one can differentiate between a benign and a malignant ulcer and, second, the morbidity and mortality following resection for gastric ulcer in competent hands are remarkably low.

No one, however, well trained in x-ray interpretation or gastroscopic examination or any method of investigation known at the present time can tell whether a gastric ulcer in its early stages is benign or malignant. The gross appearance of the ulcer after removal is frequently noncommittal and only by careful microscopic examination can its true nature be determined. All pathologists of experience recall instances where only a small area of the wall of the ulcer showed the characteristic appearances of malignancy.

Just what percentage of benign ulcers ultimately undergo malignant degeneration cannot be accurately determined. An individual proved to have gastric malignancy not infrequently gives a history of years of epigastric distress suggesting ulcer and occasionally, in addition, there has been x-ray evidence to support this diagnosis. In various clinics the incidence of degeneration has been estimated to be between 3 and 10 per cent. This alone, if for no other reason, would be more than enough to justify operation in all cases.

In addition to this a certain number of gastric ulcers are complicated by hemorrhage, some patients dying without benefit of surgery, some dying as the result of surgery and hemorrhage, and some recovering in spite of surgery done at an inopportune time. A certain percentage of these ulcers perforate, followed by an appreciable mortality regardless of the method of treatment. Some individuals having a palliative emergency operation for hemorrhage or perforation will subsequently need to undergo a second operation for one of a variety of reasons.

The medical cure of gastric ulcer can never be counted upon and many individuals suffering from the disease go through life as semi-invalids who might otherwise be normal individuals if given the benefit of surgery.

The present method of procedure in many clinics is to treat all gastric ulcers initially medically for a period of time, usually several weeks. If healing is thought to be taking place by remission of the patient's symptoms, by x-ray and gastroscopic examination, and by disappearance of occult blood in the stool, the regime is continued. That this method of deduction may too often be entirely fallacious has been the experience of many observers. The sad sequence of events may be as follows: symptoms and findings may improve regardless of the nature of the lesion and the doctor and the patient both feel assured that everything is progressing favorably. The patient subsequently has a return of symptoms but is not particularly disturbed until some months later when upon re-examination the lesion is undoubtedly malignant and frequently not responsive to any type of therapy. This sequence of events occurs too frequently to make the medical treatment of gastric ulcer a safe procedure.

In the light of the safety of modern surgery, the result of many new discoveries which are too well known to recount at this time, re-evaluation of medical versus surgical treatment of many lesions is long overdue. Gastric ulcer is an outstanding example.

The mortality of subtotal gastric resection for gastric ulcer in experienced hands is unbelievably small, considerably less than that for duodenal ulcer because the duodenal stump is away from the lesion and its adequate inversion without damage to the common duct is easily accomplished. Jejunal ulcer, the bugbear of surgery for duodenal ulcer, for all practical purposes does not occur following gastric resection for gastric ulcer. The postoperative course and subsequent complete relief of symptoms are with few exceptions most gratifying.

In the whole realm of surgery there are few more disappointing chapters than that associated with the therapy for cancer of the stomach. If cure is ever to be expected in any appreciable percentage of cases, it will be in those individuals where the diagnosis is only made by the microscope and never where the gross appearance is self-evident.

Briefly, then, surgery is indicated for all gastric ulcers because:

1. There is no method of differentiation between benign gastric ulcers and ulcers showing early malignancy.
2. Because of their complications, namely, hemorrhage and perforation.
3. Because there is no sure permanent medical cure for gastric ulcer.
4. Because of the safety of gastric resection and subsequent satisfactory result to the patient.

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# Recent Advances in Surgery

Conducted by Alfred Blalock, M.D.

## CLINICAL INVESTIGATION AND EVALUATION OF FOUR HUNDRED SIXTEEN CASES CONSECUTIVELY OPERATED UPON FOR PEPTIC ULCER

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### INTRODUCTION

PEPTIC ulcer is primarily a medical disease. Surgery has a place in its treatment only when complications develop. In the past, surgical procedures were done on an empirical basis. The results of this surgery have proved unsatisfactory.

The relationship between excessive acid and the occurrence of peptic ulcer has been emphasized through experimental and clinical work of Wangensteen and associates[1], Matthews and Dragstedt[2], Mann and Williamson[3], and others. They have shown that no longer is an empirical approach necessary to the problem of peptic ulcer, but it can now be approached scientifically on the basis that the most important single factor in the prevention of recurrence is the control of acid secretion by the stomach.

Most of the controversy today is with regard to the surgical procedure which will best accomplish the purpose of abolishing or greatly diminishing acid secretion.

It is now generally agreed that subtotal gastric resection is the most satisfactory surgical treatment for peptic ulcer. Partial gastrectomy has attained its present position only in the last twenty to twenty-five years in this country. Prior to this time various and ingenious operations had been devised in an attempt to attain a satisfactory cure for peptic ulcer. Gastrojejunostomy excision of the ulcer, operations on the pylorus, gastroduodenostomy, the Devine and Von Eiselsberg exclusion operations, as well as Connell fundusectomy, or combinations of these procedures had been attempted. Each of these operations had its staunch advocates who presented seemingly sound arguments for their choice. Notwithstanding the sincere enthusiasm of the early pioneers in surgery, the operative procedures they so vigorously defended had no real, firm physiologic foundation which could endure.

The popularity of gastrojejunostomy in the treatment of duodenal ulcer was based mainly on the supposedly high incidence of good results, technical ease of performance, and the low mortality. Unfortunately, however, many

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failed to receive relief from this procedure either because of persistence of ulcer or because of the occurrence of gastrojejunal ulcer.

The incidence of recurrent ulcer following gastrojejunostomy has been reported as varying from 3 to 30 per cent. St. John[4] reported 6.9 per cent marginal ulcer following gastrojejunostomy, Balfour,[5] 4 per cent recurrent ulcer and 9 per cent postoperative hemorrhage. Berg[6] noted incidence of 30 per cent recurrence; Walters,[7] 3 per cent; Marshall and Kiefer,[8] 24 per cent; Lahey,[9] 16 per cent; and Church and Hinton,[10] 23.8 per cent.

European surgeons had already discarded gastrojejunostomy and were employing subtotal gastric resection. Gradually the value of subtotal gastric resection began to be appreciated in this country. Hinton,[11] reported that he had been doing subtotal gastrectomy for peptic ulcer since 1932. Walters and associates[12] reported that in 1940 gastrojejunostomy constituted 55 per cent of operations for duodenal ulcer at the Mayo Clinic and gastrectomy slightly more than 40 per cent. In 1942 this was reversed with gastrectomy being done in over 57 per cent and a decrease of gastrojejunostomy to 41 per cent. Counseller and associates[13] reported that in 1944 at the Mayo Clinic, gastrectomy was done in 62 per cent of the cases and gastrojejunostomy in 37 per cent. Marshall,[14] at the Lahey clinic, reported that in 395 cases of peptic ulcer, 318 patients had subtotal gastric resections and 75 had gastrojejunostomies done. Sanders,[15] reported that in 1940 subtotal gastric resection was done in 50 per cent of the cases, and in 1945 in 75 per cent of the cases.

With the acceptance of subtotal gastric resection, considerable difference of opinion arose as to the technique. The main differences concern themselves with the extent of the resection, the length of the proximal or afferent duodenal jejunal loop, and excision of the duodenal ulcer.

The following surgeons have been ardent proponents of extensive gastric resections for ulcer: Finsterer and Cunha,[21] Lewisohn,[18] Berg,[6] Lahey and Marshall,[17] Allen and Welch,[19] Steinberg,[20] and Wangensteen and Lamin.[16]

Advocates of the smaller gastric resection are Rienhoff,[22] Hunt,[23] Sanders,[15] Holman and McSwain,[24] Strauss and associates,[25] and Heuer and Holman.[26] These men favor the smaller resection because they believe reoperation is less difficult in the event of a recurrent ulcer. They further believe that extensive resection results in unfavorable postoperative symptoms, and that sacrificing so great an amount of stomach will not proportionately increase the degree of achlorhydria or lessen the number of recurrences.

The length of the afferent loop has also been the subject of much discussion. Lahey[27] has been an advocate of the employment of a long proximal loop. He based his contention on the following items: (a) alkaline jejunal contents are dumped into the residual gastric pouch and aid in lowering gastric acidity; (b) residual gastric pouch empties better; (c) possibility of postoperative obstruction of proximal loop is lessened; (d) reoperation is made easier when stomal ulcer occurs.

Wangensteen[28] has emphasized the importance of utilizing a short afferent proximal duodenojejunal loop in the gastrojejunal anastomosis in the Billroth

II pattern. He based his views on clinical and laboratory data. He stressed the importance of the secretin factor, spatial separation, and probability of increased susceptibility of successively lower segments of the small intestine to injury by acid gastric secretions. Merendino and co-workers[29] reported that extensive gastric resection (75 per cent) in dogs when accompanied by a long afferent duodenojejunal loop was followed by a high incidence of spontaneous gastrojejunal ulcer. When histamine-in-beeswax was administered to such dogs, stomal ulcer occurred regularly. When gastrointestinal continuity was re-established by a short afferent duodenal loop in the Billroth II plan of operation, stomal ulcer after extensive gastric resection could not be provoked even when histamine-in-beeswax was administered. Maier and Grossman[30] stated that the more distal the loop of jejunum which is used for gastrojejunal anastomosis the more likely is jejunal ulceration to occur. Kiefer[31] reporting the results of gastric resection at the Lahey Clinic, noted a recurrence rate of 11.4 per cent following gastric resection for duodenal ulcer in cases where the long proximal loop was employed. Lewisohn,[32] in a recent article, took issue with those who perform subtotal gastric resection for ulcer and leave the duodenal ulcer in situ. He contended that removal of the ulcer is a necessary part of the operative procedure and insisted that the line of resection should be below the ulcer. He felt that leaving any part of the pyloric antrum, even if the antral mucosa is removed, is not a satisfactory operation. This opinion is shared by Lahey,[9] Hinton,[11] and Sanders.[15]

On the contrary, some surgeons (Steinberg,[20] Mage,[33] Colp and associates,[34] Wolfson and Rothenberg,[35] and Wilson[36]) did not believe it necessary to remove the duodenal ulcer itself to prevent recurrent ulcer after extensive gastric resection.

The success or failure of operative procedures for ulcer in the past has been evaluated mainly on the basis of recurrent ulceration. There have been few comprehensive follow-up studies which completely evaluated the functional end results. In a recent comprehensive study of 195 patients in whom resection was done for duodenal ulcers, Allen and Welch[19] reported the results in the 129 patients on whom follow-up studies were done. The over-all mortality was 5.1 per cent, with an elective mortality of 2.5 per cent. Sixty-nine per cent of the patients were graded as "excellent." These patients were entirely asymptomatic. An additional 18 per cent had trivial symptoms such as intolerance to a fatty meal or a rare attack of nausea after a heavy meal, and were also included in the "excellent" results. The patients listed as "satisfactory" comprised 6 per cent of the group, and were those who were improved by the operation but still had symptoms requiring medical care or special diet. Definitely poor results occurred in about 7 per cent of the group. The "poor" results consisted of three cases of recurrent ulcers, 2.3 per cent; three cases of postoperative hemorrhage without evidence of ulcer, 2.3 per cent; and three cases of severe postresection symptoms, 2.3 per cent.

Rienhoff[22] in a recent paper advocated the return to a "conservative" gastric resection for duodenal ulcer. In a follow-up study of 260 patients operated

upon, he found it necessary to subject 29 of the 255 who survived the operation to re-operation for recurrent ulcer, an incidence of 11.3 per cent. Hemorrhage occurred postoperatively in 26, or 10 per cent of the follow-up cases in addition, 42 patients, or 16.3 per cent, complained of pain. He reported a 2 per cent mortality in the series.

Miller,[37] in reporting results of 230 resections for peptic ulcer, noted mortality of 2.8 per cent for elective surgery. He stated that 90 per cent of the patients were cured, and 10 per cent improved. No mention was made of recurrences.

McClure and Fallis,[38] doing extensive gastric resection, reported a recurrence rate of 4 per cent and suspicion of recurrence in an additional 4 per cent. They stated that these recurrences occurred in patients who had had limited resections. Seventy-five per cent of their patients were reported as "excellent" or "good" results, 4.2 per cent as "fair," 8.6 per cent as "poor," and 8.6 per cent were not classified.

Walters and co-workers[39] reported 212 consecutive operations on a selected group of patients. Follow-up was carried out on 197 patients. The operative mortality was 1.9 per cent; 2.5 per cent developed anastomotic jejunal ulcers, 83.5 per cent of the patients were well without restriction of diet, and 14 per cent required restrictions of diet or activity, or both.

Sanders,[15] who advocates a 55 to 60 per cent resection together with the excision of the duodenal ulcer, reported an incidence of recurrent ulcer of 8 per cent, and a mortality of 3 per cent.

Berg[6] reported six recurrences, 1.1 per cent in a series of 516 cases.

Dragstedt[40] has stimulated a renewed interest in vagotomy for the treatment of peptic ulcer. At the present time it is not possible to evaluate this procedure because of the recentness of its re-introduction in the therapy of peptic ulcer. It will be some years before vagotomy can be thoroughly evaluated. This operation is being given a fair clinical trial by several competent investigators. In the meantime, it is important that one maintain an open mind and neither hastily condemn or hastily praise the procedure.

## DISCUSSION OF PROBLEM

The present study was conducted to survey and evaluate results of the surgical procedures in the treatment of peptic ulcers at the University of Minnesota Hospitals from Jan. 1, 1940, to July 1, 1945.

Four-hundred sixteen patients consecutively operated upon for septic ulcer were considered in this investigation. All were followed by questionnaire to the patient, and by clinical examination in the outpatient department.

Since 1940, this clinic has set aside one morning each week for patients who have had, or will have, gastrointestinal surgery. These patients are seen by the Chief of the Department of Surgery, and members of his staff interested in the problem of peptic ulcer. An attempt is made to maintain complete follow-up of the patient's status postoperatively by having the patient report to the clinic one week following dismissal from the hospital, then one month later;

then at three-month intervals for a period of one year. During the second year following the operation, the patient reports every six months. Following the second year he is examined once a year thereafter. If the patient does not report for checkup, periodic letters are sent to him, urging his return for examination. In the event he is unable to do so, a written report of his present health is requested. The results of these periodic visits and the information obtained by the questionnaires form the basis of this report.

QUESTIONNAIRE

NAME _____

DATE _____

HOSPITAL NO. _____

We are interested in knowing about your digestion since your operation for ulcer. We would appreciate careful answers to the following questions. You may write your answers to the questions in the space provided below for each question. If the space provided is not sufficient you may use the back of this letter.

1. How is your general health at the present time?
   Good or otherwise. Explain.
2. Are you free from pain?
   Have you found blood in the stool? Have you had tarry stools?
   Has there been any vomiting?
   Are you having any difficulty with your digestion?
   List any specific complaints.
3. Have you gained, remained the same, or lost weight?
   Give amounts and period of time.
   What is your height?
   What is your present weight?
4. Are you able to eat 3 regular full meals a day? Give an example of an average meal for each period of the day.
5. Are you able to eat all foods?
   List any and all foods which you feel give you trouble.
6. Do you drink milk? Did you drink milk before operation?
7. Are you able to work? What type of work do you do?

   How soon did you return to work after operation? We should like you to continue to have periodic checkups in this clinic. A self-addressed envelope is enclosed for your convenience in returning this questionnaire.

In evaluating results of subtotal gastric resections in these cases, the following aims of any surgical procedure were considered: (1) to rid the patient of the disease; (2) to restore him to a state of health as normal as possible; (3) to not unduly endanger the life of the patient; (4) not to produce a result carrying more serious implication than the original disease for which the patient was treated.

The investigation and evaluation covered the state of health of the patient postoperatively, presence or absence of symptoms for which he was operated upon, occurrence of new symptoms more serious than the original, quantitative and qualitative food intake, digestive function, ability to maintain normal nutrition, ability to carry on normal occupations, and the patient's own evaluation of the results of the operation.

## OPERATIVE PROCEDURE

In 1938 and 1940, this clinic began a search for an operation which would deal satisfactorily with the ulcer problem. Lannin[41] reported findings of laboratory investigation. In 1940 the clinical phase of the program was begun and three types of operation were performed for duodenal ulcer, namely: Groups III, IV, and IVA. The Group IV was discontinued because results indicated it was an unsatisfactory operation. Since 1941 the standard procedures have been Groups III and IVA.

Group III operation consists of at least 75 per cent resection, followed by a retrocolic anastomosis with the jejunum at the duodenojejunal junction producing a short, afferent loop with inversion of the lesser curvature in the Hofmeister pattern.

Group IVA differs from Group III only in the handling of the duodenum. In this instance, the pyloric antrum is sectioned about two to three finger-breadths proximal to the pyloric sphincter and the antral mucosa is excised, employing the pyloric sphincter and the antral musculature for closure. The Group IVA procedure is utilized only in those cases of the so-called difficult or irremovable duodenal ulcer.

Group IV differs from the IVA operation in that the antral mucosa is left intact. Operative Groups III, IV, and IVA are illustrated in Fig. 1.

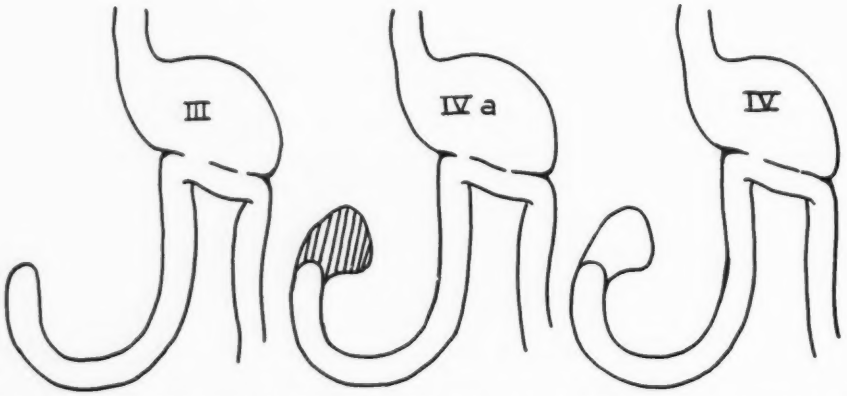


Fig. 1.—Surgical procedures (Groups III, IVa, and IV) in the treatment of peptic ulcer.

## CLINICAL OBSERVATIONS

In any discussion of peptic ulcer, duodenal ulcer should be considered apart from the gastric ulcer. The duodenal ulcer represents a different problem. There is always the possibility that malignancy is present in the gastric ulcer. Prolonged observation and medical therapy may unfavorably affect the outcome of the patient with a gastric lesion by delaying surgery until the lesion has become inoperable from a curative viewpoint. Although typical lesions of benign ulcer or carcinoma are not difficult to diagnose, there are many instances where,

despite all diagnostic aids, it is not always possible to make a definite diagnosis until the permanent microscopic sections are interpreted. Wangensteen[43] noted many reversals of diagnoses whether made by clinician, radiologist, gastroscopist, surgeon at operation, or pathologist. A more critical attitude toward gastric ulcer should be adopted so that patients will be referred by the internist for resection at an earlier date. Certainly questionable lesions should be given three to four weeks medical management to determine whether or not healing will occur. Even if healing does occur, some lesions will turn out to be carcinomatous.

In the duodenal ulcer, medical management should be carried out for an extended period of time, since the majority of patients can be adequately controlled. It is only in cases where medical management has proved ineffective that surgery should be undertaken.

The 416 cases therefore were divided into two series. Series I consisted of those cases in which the problem was that of duodenal ulcer, and Series II were those with ulcerations on the gastric side of the pylorus.

### LOCATION OF ULCER

In the 416 cases of peptic ulcers followed, 253 cases, or 61 per cent, were duodenal; 213 patients were male and 40 female, a ratio of 5 to 1. Gastric lesions totaled 90 cases, or 21.5 per cent; 72 males and 18 females, a ratio of 4 to 1. The remaining 73 cases, or 17.5 per cent, consisted of duodenal and gastric lesions, duodenal and gastrojejunal occurring together, and gastrojejunal lesions alone. In this group there were 58 males and 15 females. Complete totals revealed that males outnumbered females by a ratio of 4.6 to 1. The location of the ulcer according to sex is shown in Table I.

TABLE I. LOCATION OF ULCER

| | MALE | FEMALE |
|---|---|---|
| Duodenal | 213 | 40 |
| Duodenal and gastrojejunal | 15 | 3 |
| Duodenal and gastric | 28 | 8 |
| Gastrojejunal | 15 | 4 |
| Pyloric | 7 | 2 |
| Gastric | 65 | 16 |
| Total cases: 416 | 343 | 73 |

### CASES WITH PREVIOUS SURGERY

Table II shows the number of cases in which previous surgery had been done. Forty patients, or 9.6 per cent, had surgical repair of free perforations. Forty had gastroenterostomies. Six patients had small resections and one patient had the Devine exclusion operation. Two had local excision of ulcer. In some instances, multiple operative procedures had been done on the same patient.

### INDICATIONS FOR SURGERY

Indications for gastric resections were intractable pain, hemorrhage, and obstruction. Intractable pain was the single consideration in 85 of the 416

TABLE II. CASES WITH PREVIOUS SURGERY

| LOCATION OF ULCER | TOTAL NO. OF CASES | SURGICAL REPAIR OF PERFORATION | GASTROENTEROSTOMIES | SMALL RESECTIONS | OTHER |
|---|---|---|---|---|---|
| Duodenal | 253 | 25 | 10* | | |
| Pyloric | 9 | 1 | | | |
| Gastric | 81 | 3 | 2* | | |
| Duodenal and gastrojejunal | 18 | 4 | 15 | | |
| Duodenal and gastric | 36 | 4 | 1* | | |
| Gastrojejunal | 19 | 3 | 12 | 6 | 1 Devine exclusion<br>2 Local excision ulcer |
| Total | 416 | 40 | 40 | 6 | 3 |

*No evidence of gastrojejunal ulcer at the time of surgery and examination by pathologist.

cases, or 20 per cent of the patients who were operated upon for ulcer in this clinic. These patients were unable to control the pain under medical treatment. Pain occurred in combination with other symptoms in 316, or 76 per cent of the cases.

*Acute massive hemorrhage,* which endangers life, constitutes a major problem in the handling of the ulcer patient. Whether bleeding will stop or continue is always questionable. In the younger individual bleeding usually will cease spontaneously under conservative therapy. However, there were, in the study, five patients under the age of 45 years whose bleeding persisted. Youngest of these was a 14-year-old boy who finally needed emergency surgery. The decision to operate for acute hemorrhage in the patient over 45 years, demands careful consideration of all findings in the individual patient. Age and the degree of arteriosclerosis appeared to be important factors in the mortality of the older age group. Twenty-six patients were admitted because of acute massive hemorrhage. Of this group, 22 underwent emergency surgery with ensuing mortality of 7, or 31 per cent. The youngest fatality was 33 years of age, while all others were over 50 years. Massive hemorrhage occurred in all cases. Six patients had bled to low levels with associated drops in blood pressure to shock levels. Despite repeated transfusions, hemorrhage continued with repeated drops in blood pressure to shock levels, indicating that a fairly large vessel was open in the base of the ulcer. At operation the patients with duodenal ulcer were bleeding from the gastroduodenal artery or one of its branches.

The longest period of hemorrhage prior to surgery was thirty-eight days, and the shortest four. None of the patients were operated upon in the early course of their hemorrhage. Conservative therapy had been attempted, but had proved unsuccessful. Surgery was done as a last resort with the full realization that these patients were poor surgical risks.

The amount of blood transfused prior to surgery varied from 3,000 to 9,000 c.c. Attempts to establish good preoperative hemoglobin levels were unsuccessful because the patients' blood loss continued to exceed the replacement.

Six patients died from unavoidable complications. One patient (M.M.) died on the third postoperative day from acute hemorrhage due to erosion of a

duodenal ulcer into the gastroduodenal artery. She had previously had a gastric resection for a bleeding gastric ulcer and the presence of a duodenal ulcer was not detected at surgery. The mortality in the group of patients who were operated upon as an emergency for acute hemorrhage is indicated in Table IV.

In 12 cases, or 2.7 per cent, hemorrhage occurred without any other accompanying symptom, the patient having little or no warning of the onset. This constiutes a very important indication for surgery because of the difficulty of managing such an individual by conservative means. These patients should be operated upon to prevent future episodes.

History of hemorrhage associated with pain was given in 104 cases, or 24 per cent; 57, or 13 per cent, had hemorrhage, pain, and vomiting; and 43, or 10.3 per cent, had hemorrhage, pain, and obstruction.

Hemorrhage occurred as a symptom in 51.6 per cent of the cases.

*Obstruction* as the only symptom was found in 3 cases. When associated with severe pain, it was found to be present in 47 cases, or 11.2 per cent. Obstruction, pain, and hemorrhage occurred in 43 cases, or 10.3 per cent.

The indications for surgery are shown in Table III.

TABLE III. INDICATIONS FOR SURGERY

| | SERIES I | | SERIES II | |
|---|---|---|---|---|
| | NUMBER OF CASES | PER CENT | NUMBER OF CASES | PER CENT |
| Pain | 65 | 19.9 | 20 | 22.2 |
| Hemorrhage | 9 (3)* | 2.7 | 3 (1)* | 3.3 |
| Obstruction | 3 | 0.9 | | |
| Pain and hemorrhage | 77 (10)* | 23.6 | 27 (4)* | 30.0 |
| Pain and vomiting | 46 | 14.1 | 19 | 21.1 |
| Pain and obstruction | 41 | 12.5 | 6 | 6.6 |
| Pain, vomiting, and hemorrhage | 47 (3)* | 14.4 | 10 (2)* | 11.1 |
| Pain, hemorrhage, and obstruction | 38 (3)* | 11.6 | 5 | 5.5 |
| | 326 (19)* | | 90 (7)* | |

*Twenty-six patients admitted with acute massive hemorrhage, of which twenty-two were operated upon as an emergency; 394 patients were operated upon as elective procedures.

## MORTALITY

The over-all mortality in the 416 patients operated upon was 19 patients, or 4.5 per cent. This includes the seven cases described in Table IV of emergency operations for acute hemorrhage. Twelve deaths, 2.9 per cent, occurred as a result of elective procedures. Eight cases were classed as unavoidable deaths, and 4 were related to surgical complications. These operations were done by 4 surgeons and 6 surgical residents. The immediate mortalities of elective operations are described in Table V.

TABLE IV A

| | NUMBER OF CASES | NUMBER OF DEATHS | PERCENTAGE |
|---|---|---|---|
| Elective surgery | 394 | 12 | 3.0 |
| Emergency surgery | 22 | 7 | 31.8 |
| Over-all | 416 | 19 | 4.5 |

In response to questionnaires, it was learned that 18 patients had died since leaving the hospital. The cause of death, in each instance, is indicated in Table VI. From the information received, there were no deaths relating to operation

TABLE IV. MORTALITY OF EMERGENCY CASES OF ACUTE HEMORRHAGE

| HOSP. NO. NAME, AGE, AND SEX | DIAGNOSIS | ADMISSION HB. (GM.) | DURATION OF BLEEDING (DAYS) | PREOP. HB. (GM.) | OPERATION AND DATE | AMT. BLOOD TRANSFUSED PREOP. (C.C.) | CAUSE OF DEATH (POST-MORTEM) |
|---|---|---|---|---|---|---|---|
| 700429 (A.C.) 33 (m) | Duodenal | 7.6 | 4 | 5.84 | Group III (6/13/41) Posterior wall duodenal ulcer, ligation gastro-duodenal artery | 3000 | Died in O. R. at conclusion of operation: rheumatic heart disease, aortic regurgitation, healed aortic and mitral valvulitis, pulmonary edema |
| 711193 (E.D.) 71 (m) | Duodenal | 6.5 | 8 | 9 | Group III (8/27/41) Posterior wall duodenal ulcer, ligation gastro-duodenal artery | 6750 | 9th P.O. day: renal arteriosclerosis with uremia, pulmonary embolus; localized pancreatitis with fat necrosis peritonitis |
| 719254 (K.D.) 56 (m) | Duodenal | 8.3 | 11 | 11.0 | Group III (7/14/42) Bleeding from gastro-duodenal artery, ligated proximally and distally; ulcer perforated onto pancreas | 2750 | 8th P.O. day: acute pancreatitis with necrotic area in head of pancreas; peritonitis, pulmonary atelectasis |
| 741060 (M.B.) 50 (f) | Duodenal | 7.7 | 9 | 9.75 | Group III (3/1/44) Posterior duodenal wall ulcer, ligation branch gastro-duodenal artery | 3800 plus 1300 (plasma) | Immediately P.O.: acute recurrent endocarditis with mitral stenosis and insufficiency; acute fibrinous pericarditis bilateral pulmonary edema |
| 743027 (N.P.) 61 (m) | Gastric | 4.5 | 10 | 9.7 | Group III (4/27/44) ulcer on lesser curvature | 6000 | 11th P.O. day: bronchopneumonia with pulmonary abscesses; septicemia, right and left heart failure. |
| 747824 (M.M.) 79 (f) | Gastric and duodenal | 5.4 | 16 | 6.7 | Group III (11/3/44) Bleeding gastric ulcer | 9000 | 3 Days P.O.: acute hemorrhage from erosion of duodenal ulcer into gastro-duodenal artery |
| 750284 (J.J.) 75 (m) | Gastric | 10.6 | 30 in Local Hosp. 8 in U. of M. Hosp. | 12.3 | Group III (12/29/44) Bleeding prepyloric ulcer | 3450 (Also transfused at local hosp.) | 12 Hr. P.O.: coronary thrombosis; cerebral arteriosclerosis with encephalomalacia |

for ulcer. Fifteen patients were lost for follow-up. Every attempt to contact these patients had been made without success.

### AGE INCIDENCE

The average age of the patients in Series I was found to be 45.8 years. The youngest patient was a male who was operated upon at the age of 14 years for recurrent massive hemorrhage from a duodenal ulcer, which began at 10 years of age. The oldest patient was a man, aged 85 years.

In Series II, the average age was 54.3 years. The youngest patient was 23 years, and the oldest, a man, 75 years. Table VII indicates the age distribution according to sex and age period for Series I and II.

TABLE V. IMMEDIATE MORTALITIES OF ELECTIVE OPERATIONS

| HOSPITAL NO. | NAME | AGE (YR.) | SEX | DIAGNOSIS | OPERATION | DATE | CAUSE OF DEATH |
|---|---|---|---|---|---|---|---|
| 684265 | R.D. | 57 | f | Duodenal | Group IV | 2/19/40 | Postoperative septicemia; abscess of liver; anomalous insertion of common bile duct into pylorus; distention of proximal loop between ligament of Treitz and anastomosis |
| 665654 | L.T. | 71 | f | Gastric | Group III | 10/14/40 | Pulmonary embolus |
| 630162 | E.N. | 37 | f | Duodenal | Group III | 4/3/41 | Blood transfusion reaction with anuria and uremia |
| 673523 | L.W. | 58 | m | Duodenal | Group III | 8/5/41 | Perforation of duodenal stump with peritonitis; bronchopneumonia and pulmonary abscesses |
| 711286 | A.E. | 70 | m | Benign pyloric | Group III | 11/19/41 | Acute pancreatic necrosis of unknown etiology; anastomosis was in good order |
| 646913 | G.F. | 52 | m | Duodenal and gastric | Group III | 12/17/41 | Pneumonia |
| 725030 | E.B. | 42 | m | Gastro-jejunal | Group III | 9/28/42 | Generalized peritonitis; leakage of suture line, colon, and gastrojejunal anastomosis |
| 715944 | J.J. | 57 | m | Gastric | Group III | 11/18/42 | Died during surgery: shock and hyperthermia, temp., 107° F. At post-mortem examination: pulmonary atelectasis, edema, cysts of pituitary, chronic passive congestion liver and spleen, renal and cerebral arteriosclerosis |
| 703621 | W.N. | 44 | m | Duodenal | Group III | 11/18/42 | Subarachnoid hemorrhage; small cerebral aneurysm and cerebral arteriosclerosis |
| 718621 | J.K. | 40 | m | Duodenal | Group III | 6/10/43 | Severe coronary sclerosis with multiple coronary thromboses |
| 746468 | E.C. | 66 | f | Duodenal | Group III | 8/7/44 | Pulmonary embolus |
| 752875 | A.F. | 63 | m | Duodenal | Group III | 3/12/45 | Duodenal fistula, right and left subphrenic abscesses, peritonitis, ruptured gall bladder. |

TABLE VI. LATE MORTALITIES

| HOSPITAL NO. | NAME | AGE (YR.) | SEX | DIAGNOSIS | OPERATION | DATE | CAUSE OF DEATH | DATE OF DEATH |
|---|---|---|---|---|---|---|---|---|
| | | | | | *Series I* | | | |
| 741509 | C.C. | 60 | m | Duodenal | Group III | 7/17/41 | Coronary thrombosis, arteriosclerosis | 2/2/46 |
| 694321 | P.P. | 74 | m | Duodenal | Group III | 3/26/43 | Unknown (Reported well until death) | 1946 |
| 755561 | A.L. | 58 | m | Duodenal | Group IVA | 5/28/45 | Pyelonephritis with uremia | 11/4/45 |
| 657618 | E.M. | 58 | m | Duodenal | Group IV | 7/30/40 | Cardiac death; mitral stenosis with cardiac decompensation | 8/6/45 |
| 746167 | F.D. | 63 | m | Duodenal | Group III | 7/27/44 | Pulmonary hemorrhage | 11/30/44 |
| 743007 | E.M. | 62 | f | Duodenal | Group III | 4/17/44 | Coronary thrombosis | 4/30/44 |
| 705300 | C.K. | 68 | m | Duodenal | Group IVA | 3/25/41 | Cerebral hemorrhage | 2/21/45 |
| 739932 | M.S. | 32 | f | Duodenal | Group III | 2/25/44 | Coronary thrombosis | 5/2/45 |
| | | | | | *Series II* | | | |
| 683543 | W.C. | 51 | m | Duodenal and gastric | Group III | 12/31/40 | Nephritis | 5/26/46 |
| | | | | | *Series III* | | | |
| 686389 | M.B. | 36 | f | Pyloric | Group III | 2/26/40 | Lymphosarcoma of neck with metastases to mediastinal nodes | 7/8/40 |
| 755258 | H.W. | 52 | m | Gastric | Group III | 6/15/45 | Pulmonary tuberculosis | 9/29/45 |
| 608023 | S.H. | 59 | f | Pyloric and gastric | Group III | 8/13/40 | Metastases from carcinoma of cervix | 9/10/43 |
| 657025 | W.F. | 73 | m | Gastric | Group III | 8/31/43 | Metastases from carcinoma of lip | 9/28/43 |
| 722535 | M.G. | 69 | f | Gastric | Group III | 8/17/42 | Coronary thrombosis | 8/29/45 |
| 703948 | V.C. | 29 | m | Gastric | Group III | 1/5/44 | Bulbar poliomyelitis | 9/1/46 |
| 728192 | W.W. | 61 | m | Pyloric | Group III | 2/17/43 | Accidental death | 5/21/44 |
| 681266 | A.B. | 46 | f | Gastric | Group III | 10/9/40 | Suicide | 8/7/43 |
| 681361 | J.A. | 73 | m | Gastric | Group III | 3/18/41 | Cerebral hemorrhage | 2/12/45 |

### DURATION OF SYMPTOMS

Since duodenal ulcer is a chronic recurrent disease, symptoms very often occur over a long period of time. In Series I, the average duration of symptoms was found to be 12.9 years. One patient (G.D. No. 663622) with a duodenal ulcer was encountered whose symptoms extended over a 65-year period, during which time he was periodically troubled with epigastric distress. Twelve years prior to operation he was forced to remain on a Sippy diet continuously because of severity of the pain. In 1943, he was admitted for an acute perforation of a duodenal ulcer, but at that time, refused surgery. Later a subphrenic abscess was drained. On June 26, 1944, a subtotal gastric resection was done

TABLE VII. AGE DISTRIBUTION

| AGE (YR.) | MALES | FEMALES |
|---|---|---|
| | *Series I* | |
| 10-20 | 2 | 0 |
| 21-30 | 19 | 2 |
| 31-40 | 74 | 10 |
| 41-50 | 76 | 18 |
| 51-60 | 64 | 17 |
| 61-70 | 28 | 6 |
| 71-80 | 6 | 1 |
| 81- | 2 | 1 |
| | 271 | 55 |
| | Average age, 45.2<br>Youngest age, 14<br>Oldest Age, 85 | Average age, 49.0<br>Youngest age, 22<br>Oldest age, 81 |
| | *Series II* | |
| 10-20 | 0 | 0 |
| 21-30 | 2 | 0 |
| 31-40 | 9 | 2 |
| 41-50 | 20 | 2 |
| 51-60 | 19 | 8 |
| 61-70 | 17 | 5 |
| 71-80 | 5 | 1 |
| 81- | 0 | 0 |
| | 72 | 18 |
| | Average age, 52.8<br>Youngest age, 23<br>Oldest age, 75 | Average age, 55.8<br>Youngest age, 36<br>Oldest age, 71 |

and he has had no difficulty since, except for a volvulus of the cecum, which was operated upon. The patient is now 87 years of age, and feeling well.

In Series II, the average duration of symptoms was found to be 8.4 years. The shortest period of symptoms in this group was one week. This occurred in a 56-year-old woman (S.P., No. 746286) who was admitted because of massive gastrointestinal hemorrhage. She had had no previous difficulty prior to this time, and was operated upon as an emergency. A small benign gastric ulcer on the lesser curvature was found to be the source of the hemorrhage. The longest period of difficulty encountered in this series was 37 years.

### EXTENT OF GASTRIC RESECTIONS

In 1940, the extent of the resection was determined by measurement in square centimeters. Subsequently, this method of determining the amount of resection was discarded in favor of the actual weight of the specimen. It was believed that a more accurate determination could thus be accomplished. The stomach specimen was weighed after excision of all attached tissues, including omenta and fatty tissues.

In Series I, the average weight of the resected specimen in the nonobstructed patients was 182.23 Gm. The average weight in the obstructed patients was found to be considerably higher, namely, 246.14 Gm.

The surgeon must give careful consideration to the fact that the stomach of the obstructed patient is larger, and he must therefore remove a correspondingly larger amount in order to attain a 75 per cent resection.

In Series II, the average weight of the specimen in the nonobstructed patients was 207.3 Gm. as compared to 285.4 Gm. in the obstructed.

The average weights of the resected specimens in the female patients who were not obstructed were significantly smaller than in the males in the cases of duodenal and gastric ulcer. In the obstructed patients, this relationship was not uniformly seen in all the series.

Table VIII indicates the average weights of the resected specimens as to whether patients were obstructed or not, and according to sex.

TABLE VIII. WEIGHTS OF RESECTED SPECIMENS

| | NO. OF CASES | AVERAGE WT. RES. SPEC. (GM.) | MINIMUM WT. RES. SPEC. (GM.) | MAXIMUM WT. RES. SPEC. (GM.) |
|---|---|---|---|---|
| *Series I (Duodenal Ulcer, Gastrojejunal Ulcer, etc.)* | | | | |
| Obstructed | 76 | 246.14 | 115 | 550 |
| Nonobstructed | 227 | 182.23 | 95 | 390 |
| *Series II (Gastric and Pyloric Ulcer)* | | | | |
| Obstructed | 9 | 285.4 | 180 | 434 |
| Nonobstructed | 74 | 207.3 | 95 | 425 |

| | NO. OF CASES | AVERAGE WT. RES. SPEC. (MALES) | NO. OF CASES | AVERAGE WT. RES. SPEC. (FEMALES) |
|---|---|---|---|---|
| *Series I (Duodenal Ulcer, Gastrojejunal Ulcer, etc.)* | | | | |
| Obstructed | 55 | 242.8 | 21 | 251.5 |
| Nonobstructed | 196 | 186.1 | 31 | 156.91 |
| *Series II (Gastric and Pyloric Ulcer)* | | | | |
| Obstructed | 7 | 293.59 | 2 | 257.5 |
| Nonobstructed | 59 | 212.5 | 15 | 186.0 |

## GASTRIC ANALYSES

*Preoperative Gastric Analyses.*—Preoperative gastric analyses were done as a routine procedure in this clinic. Gastric acidity was determined in the morning. Breakfast was withheld from all patients. A No. 14 duodenal tube with four perforations at the tip was introduced through the nose into the stomach and continuous suction was employed. Fasting specimens were obtained and .5 mg. of histamine (0.3 mg. histamine base) were given in three consecutive doses at one-half hour intervals to provide the stimulus for gastric secretion. Gastric acidity was determined by the usual colorimetric titration, using Töpfer's reagent as the end point for free hydrochloric acid and phenolphthalein as the end point for the total acid. The maximum determination of the three periods was taken, and the average value of 71.5 degrees of free acid was found in Series I; and in Series II, 49.7 degrees.

*Postoperative Gastric Analyses.*—Postoperative acid determinations were made in the same manner as described in preoperative gastric analyses. Table IX shows the postoperative values obtained in the two series, according to sex and type of operation. A total of 229 patients had one or more determinations done. These patients were all tested with triple histamine; all other cases were excluded.

TABLE IX. POSTOPERATIVE ACID DETERMINATIONS WITH TRIPLE HISTAMINE STIMULATION

| | ACHLORHYDRIC | 1-10 DEGREES | 11-20 DEGREES | 21-30 DEGREES | 31 DEGREES PLUS |
|---|---|---|---|---|---|
| *Series I (Duodenal Ulcer, Gastrojejunal Ulcer, etc.)* | | | | | |
| MALES | | | | | |
| Group III | 99 | 2 | 4 | 3 | 9 |
| Group IV | 4 | | | | 1 |
| Group IVA | 24 | 1 | 2 | 1 | 1 |
| Total | 127 | 3 | 6 | 4 | 11 |
| FEMALES | | | | | |
| Group III | 20 | | | 1 | 1 |
| Group IV | 1 | | 1 | | |
| Group IVA | 4 | | | | |
| Total | 25 | | 1 | 1 | 1 |
| Total, Male and Female | 152 | 3 | 7 | 5 | 12 |
| Total Determinations | 179 | | | | |
| *Series II (Gastric and Pyloric Ulcer)* | | | | | |
| MALES | | | | | |
| Group III | 36 | 1 | 2 | 2 | |
| FEMALES | | | | | |
| Group III | 8 | 1 | | | |
| Total | 44—88% | 2 | 2 | 2 | |
| Total Determinations | 50 | | | | |

In the Group III operation, achlorhydria was found in 85.6 per cent of the patients of Series I; and in 88 per cent in Series II.

The result of the postoperative acid determinations indicated that achlorhydria was more easily obtained in female patients in the Group III operation. In Series I achlorhydria was found to be present in 90.9 per cent of the females as compared to 84.6 per cent in the males. No appreciable difference was noted in gastric ulcers (Series II) according to sex. Percentages for this group were as follows: males, 87.8 per cent; females 88.8 per cent.

In the Group IVA operation, achlorhydria was found in 84.8 per cent of the patients in Series I. Determinations in this operation also show achlorhydria more easily obtained in females. It was found to be 100 per cent for the females and 82.7 for the males.

The combined result of Groups III and IVA in Series I shows 85.4 per cent achlorhydria in all patients. Results further indicated that 7.4 per cent of the patients exhibited acid of 31 degrees or over. In Series II, no patients had acid determinations over 26 degrees.

In the Group IV operation, there were 71 per cent of the patients with achlorhydria found in Series I.

### EVALUATION OF PRESENT STATUS OF 416 PATIENTS CONSECUTIVELY OPERATED UPON

Many factors were taken into consideration in evaluating the patients as to their present status of health. Each patient was questioned regarding his opinion as to how he was feeling; any symptoms he might have relating to digestion, such as pain, vomiting, hemorrhage, and food intolerance; weight changes, and ability to work. Patients who stated that they had any difficulty

were requested to return to the outpatient department at an appointed time for clinical observation which included x-ray examination, hemoglobin, and other

TABLE X. RESULTS ACCORDING TO SEX

| YEAR | MALE, FEMALE | OPERATED UPON | LOST | DEATH IMMED. | DEATH LATE | FOLLOWED | EXCELL. | GOOD | SATIS. | POOR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | |
| | | | | | *7 Year Followed* | | | | | |
| 1940 | M | 42 | 4 | | 2 | 36 | 7 | 19 | 7 | 3 |
| | F | 6 | | 1 | | 5 | 1 | 3 | | 1 |
| | Total | 48 | 4 | 1 | 2 | 41 | 8 | 22 | 7 | 4 |
| 1941 | M | 39 | 2 | 5 | 2 | 30 | 5 | 22 | 3 | |
| | F | 12 | 1 | 1 | | 10 | 2 | 7 | 1 | |
| | Total | 51 | 3 | 6 | 2 | 40 | 7 | 29 | 4 | 0 |
| | | | | | *6 Year Followed* | | | | | |
| | M | 81 | 6 | 5 | 4 | 66 | 12 | 41 | 10 | 3 |
| | F | 18 | 1 | 2 | | 15 | 3 | 10 | 1 | 1 |
| | Total | 99 | 7 | 7 | 4 | 81 | 15 | 51 | 11 | 4 |
| 1942 | M | 52 | 1 | 2 | | 49 | 5 | 35 | 6 | 3 |
| | F | 9 | | | | 9 | 1 | 4 | 4 | |
| | Total | 61 | 1 | 2 | 0 | 58 | 6 | 39 | 10 | 3 |
| | | | | | *5 Year Followed* | | | | | |
| | M | 133 | 7 | 7 | 4 | 115 | 17 | 76 | 16 | 6 |
| | F | 27 | 1 | 2 | | 24 | 4 | 14 | 5 | 1 |
| | Total | 160 | 8 | 9 | 4 | 139 | 21 | 90 | 21 | 7 |
| 1943 | M | 46 | 2 | 1 | 1 | 42 | 11 | 27 | 3 | 1 |
| | F | 7 | | | | 7 | | 4 | 3 | |
| | Total | 53 | 2 | 1 | 1 | 49 | 11 | 31 | 6 | 1 |
| | | | | | *4 Year Followed* | | | | | |
| | M | 179 | 9 | 8 | 5 | 157 | 28 | 103 | 19 | 7 |
| | F | 34 | 1 | 2 | | 31 | 4 | 18 | 8 | 1 |
| | Total | 213 | 10 | 10 | 5 | 188 | 32 | 121 | 27 | 8 |
| 1944 | M | 49 | | | 1 | 48 | 15 | 24 | 8 | 1 |
| | F | 11 | | 3 | 2 | 6 | 4 | 1 | 1 | |
| | Total | 60 | 0 | 3 | 3 | 54 | 19 | 25 | 9 | 1 |
| | | | | | *3 Year Followed* | | | | | |
| | M | 228 | 9 | 8 | 6 | 205 | 43 | 127 | 27 | 9 |
| | F | 45 | 1 | 5 | 2 | 37 | 8 | 19 | 9 | 1 |
| | Total | 273 | 10 | 13 | 8 | 242 | 51 | 146 | 36 | 10 |
| 1945 Jan.-July | M | 43 | 1 | 1 | 1 | 40 | 8 | 23 | 7 | 2 |
| | F | 10 | | | | 10 | 4 | 3 | 2 | 1 |
| | Total | 53 | 1 | 1 | 1 | 50 | 12 | 26 | 9 | 3 |
| | | | | | *2 Year Followed* | | | | | |
| | M | 271 | 10 | 9 | 7 | 245 | 51 | 150 | 34 | 10 |
| | F | 55 | 1 | 5 | 2 | 47 | 12 | 22 | 11 | 2 |
| | Total | 326 | 11 | 14 | 9 | 292 | 63 | 172 | 45 | 12 |

indicated studies. All other patients reported for regular periodic checkup examinations. The patients in the survey were evaluated on the basis of their statements in answer to the questionnaires, clinical observation, and personal

TABLE X—CONT'D

| YEAR | MALE, FEMALE | OPERATED UPON | LOST | DEATH IMMED. | DEATH LATE | FOLLOWED | EXCELL. | GOOD | SATIS. | POOR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Series II, Gastric and Pyloric Ulcer* | | | | | | |
| | | | | *7 Year Followed* | | | | | | |
| 1940 | M | 9 | 1 | | | 8 | | 6 | 1 | 1 |
| | F | 6 | | 1 | 3 | 2 | | 1 | 1 | |
| | Total | 15 | 1 | 1 | 3 | 10 | | 7 | 2 | 1 |
| 1941 | M | 14 | 2 | 1 | 1 | 10 | 1 | 8 | 1 | |
| | F | 0 | | | | | | | | |
| | Total | 14 | 2 | 1 | 1 | 10 | 1 | 8 | 1 | |
| | | | | *6 Year Followed* | | | | | | |
| | M | 23 | 3 | 1 | 1 | 18 | 1 | 14 | 2 | 1 |
| | F | 6 | 0 | 1 | 3 | 2 | 0 | 1 | 1 | |
| | Total | 29 | 3 | 2 | 4 | 20 | 1 | 15 | 3 | 1 |
| 1942 | M | 11 | | 1 | | 10 | 2 | 6 | 2 | |
| | F | 4 | 1 | | 1 | 2 | | 1 | 1 | |
| | Total | 15 | 1 | 1 | 1 | 12 | 2 | 7 | 3 | |
| | | | | *5 Year Followed* | | | | | | |
| | M | 34 | 3 | 2 | 1 | 28 | 3 | 20 | 4 | 1 |
| | F | 10 | 1 | 1 | 4 | 4 | 0 | 2 | 2 | |
| | Total | 44 | 4 | 3 | 5 | 32 | 3 | 22 | 6 | 1 |
| 1943 | M | 12 | | | 2 | 10 | | 5 | 4 | 1 |
| | F | 4 | | | | 4 | 1 | 2 | 1 | |
| | Total | 16 | 0 | 0 | 2 | 14 | 1 | 7 | 5 | 1 |
| | | | | *4 Year Followed* | | | | | | |
| | M | 46 | 3 | 2 | 3 | 38 | 3 | 25 | 8 | 2 |
| | F | 14 | 1 | 1 | 4 | 8 | 1 | 4 | 3 | |
| | Total | 60 | 4 | 3 | 7 | 46 | 4 | 29 | 11 | 2 |
| 1944 | M | 19 | | 2 | 1 | 16 | 4 | 9 | 3 | |
| | F | 2 | | | | 2 | | 2 | | |
| | Total | 21 | 0 | 2 | 1 | 18 | 4 | 11 | 3 | 0 |
| | | | | *3 Year Followed* | | | | | | |
| | M | 65 | 3 | 4 | 4 | 54 | 7 | 34 | 11 | 2 |
| | F | 16 | 1 | 1 | 4 | 10 | 1 | 6 | 3 | |
| | Total | 81 | 4 | 5 | 8 | 64 | 8 | 40 | 14 | 2 |
| 1945 Jan.-July | M | 7 | | | 1 | 6 | 1 | 4 | 1 | |
| | F | 2 | | | | 2 | | 2 | | |
| | Total | 9 | 0 | 0 | 1 | 8 | 1 | 6 | 1 | 0 |
| | | | | *2 Year Followed* | | | | | | |
| | M | 72 | 3 | 4 | 5 | 60 | 8 | 38 | 12 | 2 |
| | F | 18 | 1 | 1 | 4 | 12 | 1 | 8 | 3 | |
| | Total | 90 | 4 | 5 | 9 | 72 | 9 | 46 | 15 | 2 |

interviews. The results of the cases studied were classified into four categories, namely, excellent, good, satisfactory, and poor.

The "excellent" group comprised those patients who were entirely free of symptoms, ate regular diets as to quality and quantity, maintained normal nutritional status, and were engaged in regular employment.

The patients classified as "good" enjoyed the same state of health as the "excellent" group, but were placed in this group by reason of their terminology as to how they were feeling.

The "satisfactory" group consisted of patients who stated they were doing well, but had occasional minor complaints, such as nausea, diarrhea, a feeling of fullness, or heartburn. Some patients were unable to eat as large a meal as they did prior to surgery. Included in this group also were the patients who had some food intolerances, and those who had mild symptoms of the so-called "dumping syndrome." Each patient who listed a complaint was observed clinically and was personally interviewed. It was found that generally all patients in this group were doing well and were able to carry on their regular employment.

The patients placed in the "poor" group were those who either had recurrent ulcerations, symptoms suggestive of recurrent ulcerations, or who stated they were in poor health. Patients who stated they were in poor health revealed they had distress after meals, were restricted as to quantity and quality of food, were unable to maintain normal nutrition, and unable to work.

There were 416 patients operated upon, of which 19 were immediate mortalities, and 18 late. Fifteen patients were lost for follow-up.

### RESULTS ACCORDING TO SEX

All the patients evaluated have had follow-ups for at least two years; some as long as seven years. Table X shows the results according to sex and the period of observation by years. In Series I, there were 292 cases followed. There were 245 males and 47 females, with the results shown in Table XA.

TABLE X A. RESULTS IN SERIES I, DUODENAL ULCER, GASTROJEJUNAL ULCER

| | (MALES) | | | (FEMALES) | |
|---|---|---|---|---|---|
| RESULT | NUMBER | PER CENT | RESULT | NUMBER | PER CENT |
| Excellent | 51 | 21 | Excellent | 12 | 25.5 |
| Good | 150 | 61.2 | Good | 22 | 46.8 |
| Satisfactory | 34 | 13.8 | Satisfactory | 11 | 23.4 |
| Poor | 10 | 4 | Poor | 2 | 4.3 |
| Total | 245 | 100 | Total | 47 | 100 |

It was found that the males showed 82 per cent "excellent" and "good" results as compared with 72 per cent in the females.

In the "satisfactory" group the females showed this result in 24 per cent of the cases as compared with 13.8 per cent in the males. The results of the three previously mentioned categories indicate that the females had more minor complaints. All three categories include men and women who were doing well.

In the "poor" group the percentage of results was approximately the same. Included in this evaluation was the Group IV operation which showed two poor cases in the males, and one in the female.

In Series II, there were 72 cases followed. There were 60 males and 12 females with the results shown in Table XB.

TABLE X B. RESULTS IN SERIES II, GASTRIC AND PYLORIC ULCER

| | MALES (60) | | | FEMALES (12) | |
|---|---|---|---|---|---|
| RESULT | NUMBER | PER CENT | RESULT | NUMBER | PER CENT |
| Excellent | 8 | 13.3 | Excellent | 1 | 8.3 |
| Good | 38 | 63.4 | Good | 8 | 66.7 |
| Satisfactory | 12 | 20 | Satisfactory | 3 | 25 |
| Poor | 2 | 3.3 | | | |
| Total | 60 | 100 | Total | 12 | 100 |

With the exception of two poor cases in the males, there was no appreciable difference found as to result in the sexes in this series.

### RESULTS ACCORDING TO OPERATION

Table XI shows the results according to type of operation and period of observation for years. In Series I there were 231 patients followed who had Group III; 55, Group IVA; and 6 had Group IV. In Series II, there were 72 cases followed. All patients evaluated according to type of operation have been followed for at least two years, and some as long as seven years.

The total number of patients and the percentages are given in Table XIA for the results according to type of operation.

TABLE XI A. RESULTS IN SERIES I, DUODENAL ULCER, GASTROJEJUNAL ULCER

| | GROUP III (231) | | GROUP IV A (55) | | GROUP IV (6) | |
|---|---|---|---|---|---|---|
| RESULT | NUMBER | PER CENT | NUMBER | PER CENT | NUMBER | PER CENT |
| Excellent | 48 | 20.8 | 14 | 25.5 | 1 | 16.6 |
| Good | 141 | 61.0 | 30 | 54.5 | 1 | 16.6 |
| Satisfactory | 34 | 14.8 | 10 | 18.2 | 1 | 16.6 |
| Poor | 8 | 3.4 | 1 | 1.8 | 3 | 50.0 |
| Total | 231 | 100 | 55 | 100 | 6 | 100 |

In the patients who had Group III operation in Series I, it was found that 82 per cent were doing very well. These patients were asymptomatic, observed no dietary restrictions, and were capable of carrying on regular employment.

Patients graded satisfactory totaled 14.7 per cent. They were all benefited by the operation and were enjoying fairly good health. None of the patients required medical care, except for minor complaints such as bloating, diarrhea, or heartburn, or some food intolerance. Some patients ate more frequently and others complained of symptoms of the so-called "dumping syndrome." These individuals were found to have adjusted to this difficulty by decreasing the size of the meals, eating more frequently, and allowing a short rest period following meals. All patients, with the exception of one, were capable of pursuing their

TABLE XI. RESULTS ACCORDING TO TYPE OPERATION

| YEAR | | OPERATED | LOST | DEATH IMMED. | DEATH LATE | FOLLOWED | EXCELL. | GOOD | SATIS. | POOR |
|---|---|---|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | | |
| | | | | | *7 Year Followed* | | | | | |
| 1940 | III | 40 | 3 | | 1 | 36 | 7 | 21 | 7 | 1 |
| | IV | 8 | 1 | 1 | 1 | 5 | 1 | 1 | | 3 |
| | Total | 48 | 4 | 1 | 2 | 41 | 8 | 22 | 7 | 4 |
| 1941 | III | 34 | 2 | 6 | 1 | 25 | 5 | 18 | 2 | |
| | IV | 2 | | | | 1 | | | 1 | |
| | IVA | 15 | 1 | | 1 | 14 | 2 | 11 | 1 | |
| | Total | 51 | 3 | 6 | 2 | 40 | 7 | 29 | 4 | 0 |
| | | | | | *6 Year Followed* | | | | | |
| | III | 74 | 5 | 6 | 2 | 61 | 12 | 39 | 9 | 1 |
| | IV | 9 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 3 |
| | IVA | 16 | 1 | | 1 | 14 | 2 | 11 | 1 | |
| | Total | 99 | 7 | 7 | 4 | 81 | 15 | 51 | 11 | 4 |
| 1942 | III | 49 | 1 | 2 | | 46 | 5 | 34 | 5 | 2 |
| | IV | | | | | | | | | |
| | IVA | 12 | | | | 12 | 1 | 5 | 5 | 1 |
| | Total | 61 | 1 | 2 | 0 | 58 | 6 | 39 | 10 | 3 |
| | | | | | *5 Year Followed* | | | | | |
| | III | 123 | 6 | 8 | 2 | 107 | 17 | 73 | 14 | 3 |
| | IV | 9 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 3 |
| | IVA | 28 | 1 | | 1 | 26 | 3 | 16 | 6 | 1 |
| | Total | 160 | 8 | 9 | 4 | 139 | 21 | 90 | 21 | 7 |
| 1943 | III | 47 | 1 | 1 | 1 | 44 | 9 | 28 | 6 | 1 |
| | IV | | | | | | | | | |
| | IVA | 6 | 1 | | | 5 | 2 | 3 | | |
| | Total | 53 | 2 | 1 | 1 | 49 | 11 | 31 | 6 | 1 |
| | | | | | *4 Year Followed* | | | | | |
| | III | 170 | 7 | 9 | 3 | 151 | 26 | 101 | 20 | 4 |
| | IV | 9 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 3 |
| | IVA | 34 | 2 | | 1 | 31 | 5 | 19 | 6 | 1 |
| | Total | 213 | 10 | 10 | 5 | 188 | 32 | 121 | 27 | 8 |
| 1944 | III | 47 | | 3 | 3 | 41 | 15 | 18 | 7 | 1 |
| | IV | | | | | | | | | |
| | IVA | 13 | | | | 13 | 4 | 7 | 2 | |
| | Total | 60 | 0 | 3 | 3 | 54 | 19 | 25 | 9 | 1 |

regular work. The exceptional case was an individual who gave a poor work record over many years, and also was suffering from psychoneurosis.

There were eight patients, 3.4 per cent, classified as "poor" in Series I who had Group III operation. Two patients, .86 per cent, were found to have recurrences. Two, .86 per cent, gave a history of postoperative hemorrhage. Four patients stated they were in poor health and had symptoms that did not permit their classification in the "excellent," "good," or "satisfactory" groups.

The following is a brief summary of the eight patients who had Group III operation in Series I and were classified as unsatisfactory.

CASE 1 (No. 743745).—L. B. was a man, aged 49 years, with a diagnosis of active duodenal and gastrojejunal ulcer. The patient had typical ulcer history of twenty-seven years' duration. Gastrojejunostomy had been performed in 1937. He was admitted May

TABLE XI—CONT'D

| YEAR | | OPERATED | LOST | DEATH IMMED. | DEATH LATE | FOLLOWED | EXCELL. | GOOD | SATIS. | POOR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *3 Year Followed* | | | | | |
| | III | 217 | 7 | 12 | 6 | 192 | 41 | 119 | 27 | 5 |
| | IV | 9 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 3 |
| | IVA | 47 | 2 | | 1 | 44 | 9 | 26 | 8 | |
| | Total | 273 | 10 | 14 | 8 | 242 | 51 | 146 | 36 | 8 |
| 1945 Jan.-July | III IV IVA | 40 13 | 1 | 1 | 1 | 39 11 | 7 5 | 22 4 | 7 2 | 3 |
| | Total | 53 | 1 | 1 | 1 | 50 | 12 | 26 | 9 | 3 |
| | | | | | *2 Year Followed* | | | | | |
| | III | 257 | 7 | 13 | 6 | 231 | 48 | 141 | 34 | 8 |
| | IV | 9 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 3 |
| | IVA | 60 | 3 | | 2 | 55 | 14 | 30 | 10 | 1 |
| | Total | 326 | 11 | 14 | 9 | 292 | 63 | 172 | 45 | 12 |
| | | | | | *Series II, Gastric and Pyloric* | | | | | |
| 1940 | III | 15 | 1 | 1 | 3 | 10 | | 7 | 2 | 1 |
| | | | | | *7 Year Followed* | | | | | |
| | III | 15 | 1 | 1 | 3 | 10 | | 7 | 2 | 1 |
| 1941 | III | 14 | 2 | 1 | 1 | 10 | 1 | 8 | 1 | |
| | | | | | *6 Year Followed* | | | | | |
| | III | 29 | 3 | 2 | 4 | 20 | 1 | 15 | 3 | 1 |
| 1942 | III | 15 | 1 | 1 | 1 | 12 | 2 | 7 | 3 | |
| | | | | | *5 Year Followed* | | | | | |
| | III | 44 | 4 | 3 | 5 | 32 | 3 | 22 | 6 | 1 |
| 1943 | III | 16 | 0 | 0 | 2 | 14 | 1 | 7 | 5 | 1 |
| | | | | | *4 Year Followed* | | | | | |
| | III | 60 | 4 | 3 | 7 | 46 | 4 | 29 | 11 | 2 |
| 1944 | III | 21 | 0 | 2 | 1 | 18 | 4 | 11 | 3 | 0 |
| | | | | | *3 Year Followed* | | | | | |
| | III | 81 | 4 | 5 | 8 | 64 | 8 | 40 | 14 | 2 |
| 1945 Jan.-July | III | 9 | 0 | 0 | 1 | 8 | 1 | 6 | 1 | 0 |
| | | | | | *2 Year Followed* | | | | | |
| | Total | 90 | 4 | 5 | 9 | 72 | 9 | 46 | 15 | 2 |

13, 1944, with a history of hematemesis, melena, and epigastric pain. Hemorrhage occurred on five occasions prior to admission during the previous year. He was operated upon on May 15, 1944, at which time a 75 per cent gastric resection was done. The weight of the resected specimen was 155 Gm. Operative findings were gastrojejunal ulcer perforated onto colon and active duodenal ulcer.

The patient was readmitted on Oct. 5, 1944, because of epigastric pain and hematemesis. Transfusion was given and he was treated conservatively.

The third admission was for acute onset of paroxysmal auricular fibrillation and hypertension. At this time the ulcer symptoms were well controlled by medical management. The patient's fourth admission on March 22, 1945, was for recurrence of epigastric pain and melena. He was again treated conservatively.

He was readmitted for the fifth time because of persistence of epigastric pain and recurrent hemorrhages. X-ray examination showed presence of stomal ulcer. The patient

was re-operated upon May 1, 1945, at which time a gastrojejunal ulcer was found, and 78 Gm. of stomach was removed.

The patient was last seen in the outpatient department in May, 1947, at which time he was feeling well.

CASE 2 (No. 635560).—R. D. was a man, aged 37 years, with diagnosis of obstructed duodenal ulcer. The patient had typical ulcer history for fifteen years. He was admitted to the hospital May 7, 1942, with a history of recurrent attacks of vomiting and severe epigastric pain. X-ray examination showed duodenal ulcer with fairly high-grade obstruction. He had free acid to 84 degrees. He was operated upon on May 15, 1942. Weight of the resected specimen was 220 Gm. Operative findings were large stomach with indurated pylorus and posterior wall duodenal ulcer perforated onto pancreas with considerable inflammatory reaction around entire duodenum.

The patient did quite well until December, 1947, when he had recurrence of epigastric pain and lost weight. Physical examination was negative, except for blood pressure of 210/135. X-ray examination revealed what was believed to be a carcinoma of the residual gastric pouch. Because of these findings he was re-operated upon on May 15, 1947. A stomal ulcer was found with considerable inflammatory reaction around the anastomosis. The proximal jejunal loop was somewhat longer than usual. An additional amount of stomach was excised and a short loop anastomosis was made.

CASE 3 (No. 672024).—E. B., a man, aged 34 years, was admitted to the hospital Sept. 29, 1940, with a diagnosis of chronic duodenal ulcer. He had a typical ulcer history of ten years' duration. Surgical repair of perforated duodenal ulcer had been done three years prior to admission. The patient had free acid to 90 degrees. He was operated upon on Sept. 30, 1940; weight of the resected specimen was 157 Gm. Operative findings were posterior wall duodenal ulcer perforated onto pancreas and an anterior wall ulcer in juxtaposition to pylorus. This necessitated closure of an open duodenum. The patient made an uneventful recovery.

The patient was achlorhydric on repeated examinations postoperatively. Three years after operation he began to have constant gnawing epigastric pain, and at the same time had hematemesis and tarry stools. In answer to the questionnaire, the patient stated he continues to have epigastric pain, observes a restricted diet, eats small meals frequently, and has occasional vomiting. He was admitted Oct. 9, 1947, with a small bowel obstruction and was operated upon. No marginal ulcer was found at operation. X-ray examination was negative. He has felt fairly well since.

CASE 4 (No. 667664).—W. G., a man, aged 41 years, was admitted Feb. 13, 1945, with a diagnosis of chronic duodenal ulcer with obstruction. He had a typical ulcer history of thirteen years' duration. He had three episodes of hematemesis and melena in the year prior to admission, and epigastric pain and vomiting. Vomiting increased prior to admission. X-ray examination revealed presence of active duodenal ulcer with some obstruction. He had free acid to 40 degrees. The patient was operated upon on Feb. 23, 1945. Weight of the resected specimen was 210 Gm. Operative findings were supraduodenal ulcer with marked scarring.

He did very well postoperatively, returned to his farm work, and had no digestive difficulty. Postoperative acid determination one year later showed free acid to 50 degrees.

On March 4, 1947, he began to have tarry stools and noted onset of weakness. When he reported to the clinic one week later, x-ray examination and gastroscopy did not reveal presence of any ulcer. He was treated conservatively.

On the last visit to clinic July 15, 1947, he was asymptomatic, and has remained well since this episode of hemorrhage.

CASE 5 (No. 753204).—J. W., a woman, aged 42 years, was admitted March 21, 1945, with a diagnosis of duodenal ulcer with obstruction. She had typical ulcer symptoms for ten years, consisting of epigastric pain, nausea, vomiting. Hematemesis and melena were

present on two occasions. She was operated upon on April 2, 1945. Weight of the resected specimen was 235 Gm. Operative findings were posterior wall duodenal ulcer perforated onto pancreas. The closure of the duodenum was difficult. Postoperative convalescence was complicated by development of a left subphrenic abscess which was drained.

The patient was readmitted to the hospital on Oct. 6, 1945, at which time she had evidence of small bowel obstruction. At operation volvulus and gangrene of small bowel were found. This necessitated resection of four feet of small bowel.

She was last seen in February, 1947, when she complained of pain after meals and bloating. She observed dietary restrictions and was limited to frequent small feedings. Her height is 5 feet 5 inches and she weighs 101 pounds. She appears considerably underweight. X-ray examination shows a well-functioning gastrojejunal anastomosis with no evidence of recurrent ulceration.

This patient has many home difficulties and is extremely nervous. Psychotherapy has benefited her to some degree. It may be that in the event her emotional problems were alleviated, the general health would improve.

CASE 6 (No. 740662).—R. M., a man, aged 62 years, was admitted March 14, 1944. There was typical ulcer history of three years' duration. He complained of dull constant epigastric pain and weight loss. The preoperative acids were as high as 48 degrees. The patient was operated upon March 27, 1944. The weight of the resected specimen was 155 Gm. Operative findings were posterior wall duodenal ulcer perforated onto pancreas.

Postoperatively, the patient was unable to gain weight and had multiple complaints such as epigastric pain, poor appetite, and marked weakness. X-ray examinations have been negative for presence of recurrent ulcer.

In 1946, the patient was hospitalized on the neurology service because of pain in the back and legs; parasthesia of both arms and legs; tinnitus and decreased hearing in left ear. Diagnosis of primary lateral sclerosis was made.

On May 7, 1947, a local doctor reported x-ray examination at this time showed no evidence of ulcer.

CASE 7 (No. 737643).—A. M., a man, aged 47 years, was admitted Nov. 23, 1943, with a diagnosis of duodenal ulcer. He had typical ulcer history of thirteen years' duration. He complained of epigastric pain and occasional vomiting. The preoperative acids were as high as 54 degrees. He was operated upon on Dec. 1, 1943. Weight of the resected specimen was 165 Gm. Operative findings were anterior wall duodenal ulcer.

The patient did not report for periodic checkups. This might have been due to the fact that he resided in Nebraska. In answer to the questionnaire, he stated that his health was poor, and he had frequent diarrhea and abdominal distress. He was able to carry on his work. Repeated requests for him to return for follow-up and examination have not been answered.

CASE 8 (No. 719147).—A. T., a man, aged 37 years, was admitted May 5, 1942, with a diagnosis of duodenal ulcer with obstruction. He had a typical ulcer history of nine years' duration. He complained of epigastric distress, vomiting, and melena. Fasting specimen showed 51 degrees of free acid. He was operated upon May 5, 1942. The resected specimen weighed 220 Gm. Operative findings were anterior wall duodenal ulcer.

The patient had meningitis in 1946 and is suffering from postmeningeal effects.

He last reported to the surgery clinic Jan. 28, 1947, at which time he complained of abdominal distress and diarrhea. It was necessary for him to limit the size of meals and eat frequently. He also complained of feeling weak and tired. X-ray examination showed no evidence of recurrence.

It is felt that because the patient had had meningitis, it might be a contributing factor as to the state of health at this time. The patient was considered an unsatisfactory result on the basis of the complaints.

In the two patients who developed recurrent ulcers it was felt that criteria for a satisfactory operation had not been met. One patient (L. B., Case 1), had an inadequate resection done. Because 6 cm. of jejunum were included in the 155 Gm. weight of the resected specimen, the actual weight was 135 Gm. This amount is far below the average weight of resected specimens. The other case (R. D., Case 2), developed recurrent ulcer because the proximal loop was longer than usual.

### RESULTS IN THE GROUP IVA OPERATION IN SERIES I, DUODENAL ULCER, GASTROJEJUNAL ULCER

There were 55 patients with Group IVA operation followed in Series I. Eighty per cent of these patients were enjoying very good health. Ten patients, 18 per cent of the cases, were classified "satisfactory." One patient, 1.8 per cent of the cases followed, was classified a poor result because of a recurrent gastrojejunal ulceration.

Following is a case summary of the one patient who had Group IVA operation in Series I and was classified "poor."

W. P. (No. 699799), a man, aged 58 years, had six hospital admissions. The first admission was on Sept. 24, 1940, at which time he gave a history of peptic ulcer of forty-four years' duration. Symptoms began at 14 years of age. He had had six severe hemorrhages prior to admission to the hospital on Sept. 24, 1940. In 1926, the patient had had a gastrojejunostomy performed. Subsequent to this he had three severe episodes of bleeding.

On Sept. 24, the patient was hospitalized because of presence of weakness, tarry stools, and drop in hemoglobin. Diagnosis was bleeding peptic ulcer. He was treated conservatively with good results.

The second admission was on Aug. 5, 1942. At that time he was readmitted for consideration of surgical treatment for chronic duodenal ulcer and possible stomal. He had continued to have gastric hemorrhages since the last admission. He had had little or no distress in the abdomen. The patient had been very cooperative, followed the diet well, had taken very good care of himself. In view of the recurrent hemorrhages, gastrectomy was the treatment of choice. He was operated upon on Aug. 11, 1942. The operative findings consisted of the following: There was considerable induration in the neighborhood of the duodenum. Questionable gastrojejunal ulcer was present. Because of the large amount of induration surrounding the duodenum, it was felt that in this case a Group IVA operation should be done. The weight of the resected stomach was only 75 Gm. However, although the stomach was very small, the record suggests that only a 60 per cent resection was accomplished.

The third admission was for treatment of a Colles fracture involving the right wrist.

The patient was admitted for the fourth time on Oct. 1, 1945. At that time he complained of the occurrence of tarry stools beginning on Sept. 30, 1945. This was preceded by three weeks of mild abdominal distress. It was believed this patient had a bleeding stomal ulcer. He was treated conservatively with continuous intragastric drip of milk and cream and milk of Trinesium. On conservative therapy, the patient's bleeding stopped and he was discharged on Oct. 29, 1945.

He was readmitted for the fifth time on April 22, 1946. He had been doing quite well on a medical regimen, but was admitted this time for treatment of nocturnal exertional dyspnea. Diagnosis at this time was primary hypertension and quiescent gastrojejunal ulcer.

The sixth admission was on Nov. 11, 1946. At that time the patient complained of epigastric pain coming on late after meals and relieved by food and alkaline medications. On Nov. 13, 1946, the patient was operated upon and bilateral supradiaphragmatic vagotomy

was done. X-ray examination on Jan. 22, 1947, showed absence of any evidence of pathology except for rather slow emptying into the jejunum. Patient is apparently not having any difficulty and has resumed his occupation.

It has been stated by Lewisohn[32] that in order to achieve satisfactory results the duodenal ulcer must be removed. However, in the cases followed and studied here with Group IVA operation where the ulcer was left in situ the results were gratifying, in that a low percentage of poor results was found. In the one poor case, 1.8 per cent of the patients in Series I with Group IVA operation, it was found that the patient developed a recurrence because an inadequate resection was done.

The question may naturally be asked as to why recurrent ulcers are a problem if the criteria for a satisfactory operation for ulcer have been followed. One may answer this by self-inquiry: Have the criteria been followed? Thus, a surgeon after a long tedious battle with the intra-abdominal contents of a short fat hypersthenic individual, may in his own mind feel that he has done a good operation. However, it is in that type of individual, where the stomach is small and transverse in nature, and tethered along the diaphragm making exposure difficult that one cannot *feel,* but instead should be mathematically certain that an adequate amount of stomach has been taken. It is our practice in the Clinic to excise at least 175 Gm. of stomach. This point was not followed in two cases (L. B., No. 743745, and W. P., No. 699799). Both of these patients fell into the category just mentioned. Naturally one would surmise that if recurrences are to be had, they will occur in individuals where in the criteria have not been met. It is our belief that this was the cause of recurrent ulcer in these two patients, that is, not excising enough stomach.

### RESULTS OF GROUP IV OPERATIONS

Since this study is an evaluation of 416 patients consecutively operated upon from Jan. 1, 1940, the results of the Group IV operation were also included. It was quickly appreciated that this procedure was unsatisfactory in the treatment of duodenal ulcer and, therefore, it was discontinued early in 1941.

Follow-up studies were carried out on six patients. There were two additional patients operated upon in 1940 who had Group IV operation, and then were re-operated upon within a six-month period. They have been included in the patients followed that had Group III operation.

Of the six patients on whom follow-up was done, three were doing well. The remaining three were found to be poor.

The following is a brief summary of the three cases in which Group IV operation was done.

CASE 1 (No. 694072).—C. J., a man, aged 24 years, was admitted April 6, 1940, with a diagnosis of duodenal ulcer. He had a typical ulcer history of twelve years' duration and complained of severe epigastric pain. The patient was operated upon April 11, 1940. The specimen measured 244 sq. cm. Operative findings were anterior wall duodenal ulcer with a good deal of surrounding induration.

Postoperatively the patient did well and was inducted in the Army on March 21, 1941. He received medical discharge on Oct. 22, 1943, because of marginal ulcer. Surgery was done by the Veterans Administration and a marginal ulcer was found.

CASE 2 (No. 601445).—O. M., a woman, aged 46 years, was admitted with typical history of duodenal ulcer on May 24, 1940. She previously had surgical repair of a perforated ulcer in 1920, and gastrojejunostomy in 1926. The patient continued to have intermittent periods of epigastric pain. In February, 1940, she had severe hemorrhage and onset of severe epigastric pain. She was operated upon May 24, 1940, with a Group IV operation. Operative findings were anterior and posterior wall duodenal ulcer. Weight of the resected specimen was not given. (Specimen greater curvature 18 cm., lesser 7 cm., proximal line of resection 4.5, distal 6.5.)

The patient did fairly well but had episodes of severe epigastric pain associated with ingestion of fried and fatty foods. On Sept. 26, 1941, a cholecystectomy was done. Diagnosis was chronic cholecystitis and cholelithiasis. She felt fairly well subsequently until February, 1946, when she began to have severe epigastric pain, melena, and extreme weakness. Again in the summer of 1946 she had melena and a repetition of this in November, 1946.

She was readmitted on Jan. 12, 1946 and reoperated upon Jan. 13, 1947, with Group III operation. Operative findings were long proximal loop 45 cm. plus 10 cm. of enteroanastomosis. Distance from proximal side enteroanastomosis was 15 cm.; total length 70 cm. from ligament of Treitz to gastrojejunal anastomosis. Diagnosis was gastrojejunal ulcer.

CASE 3 (No. 668620).—H. L., a man, aged 55 years, was admitted April 23, 1940, with typical history of duodenal ulcer of thirty years' duration. The symptoms were epigastric pain, bloating, and weight loss. He was operated upon April 27, 1940. Operative findings were anterior wall duodenal ulcer with considerable induration. Weight of the resected specimen was not given.

The patient did fairly well for about one year, and then began to have epigastric pain, bloating, and had to restrict his diet. He returned to the clinic in July, 1947, complaining of the symptoms mentioned. He was readmitted July 19, 1947, and reoperated upon July 28, at which time the antral segment was excised. The patient previously had had a long proximal loop and an enteroanastomosis. This was excised with a segment of stomach and a short proximal loop was made.

### RESULTS OF SERIES II ACCORDING TO TYPE OF OPERATION, GASTRIC AND PYLORIC ULCER

Because handling of the duodenum presents no technical problem, all the patients in this series were treated by Group III operation.

Of the 72 cases in which follow-up study was done, 55, or 76 per cent, of the patients were feeling very well; 15, or 21 per cent, were classified satisfactory; and 2, or 2.7 per cent, were poor.

No recurrences were found in this series.

The following is a brief summary of the two cases in this series which were classified as unsatisfactory:

CASE 1 (No. 723781).—H. S., a man, aged 58 years, was admitted to the hospital June 19, 1943. He had typical ulcer history for eight years. Symptoms consisted of epigastric pain, nausea, and vomiting. The patient had been performing gastric lavage for a period of eight weeks. He was admitted in a state of alkalosis with extrarenal uremia. The patient was very malnourished. He was operated upon June 14, 1943, after the alkalosis has been corrected and blood urea nitrogen had returned to normal. The resected specimen weighed 360 Gm. Operative findings were prepyloric ulcer and an extralumenal cicatricial obstruction of stomach and duodenum.

Postoperatively there was some improvement but the patient has never been too well. He has occasional nausea and vomiting, must eat frequent small meals, and avoids many foods. He is also subject to periods of mental depression and has arthritis of a severe degree.

CASE 2 (No. 702451).—E. L., a man, aged 47 years, was admitted to the hospital on Dec. 9, 1940, with five weeks' history of acute onset of epigastric pain, weakness, and melena. The preoperative diagnosis was probable carcinoma of the stomach. The patient was operated upon on Dec. 16, 1940. Weight of the resected specimen was 250 Gm. Operative findings were benign gastric ulcer of the mid-portion of the lesser curvature. Size of the ulcer was 2½ by 1½ cm.

Postoperatively the patient did fairly well for four years. In June, 1945, he began to have more difficulty, was underweight, complained of distress after meals and nausea, observed many dietary restrictions, and ate frequent small meals. The patient has been requested to return to the clinic by letter and even telephone in July, 1947, but he fears further surgery and is reluctant to return.

### OBSTRUCTED AND NONOBSTRUCTED CASES

Sanders,[15] in reviewing his cases, noted that the results in patients who had been obstructed prior to gastrectomy were better than in nonobstructed patients. We were interested in determining if this observation was true in our cases. Table XII indicates results in obstructed and nonobstructed patients in Series I and II.

TABLE XII. RESULTS OF OBSTRUCTED AND NONOBSTRUCTED CASES

| | | DEATH | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | OPERATED | LOST | IMMED. | LATE | FOL-LOWED | EX-CELLENT | GOOD | FACTORY SATIS- | POOR |
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | |
| Obstructed | 82 | 1 | 4 | 3 | 74 | 9 | 49 | 12 | 4 |
| Nonobstructed | 244 | 10 | 10 | 6 | 218 | 54 | 123 | 33 | 8 |
| Total cases | 326 | 11 | 14 | 9 | 292 | 63 | 172 | 45 | 12 |
| *Series II, Gastric and Pyloric Ulcer* | | | | | | | | | |
| Obstructed | 11 | 0 | 0 | 3 | 8 | 1 | 5 | 1 | 1 |
| Nonobstructed | 79 | 4 | 5 | 6 | 64 | 8 | 41 | 14 | 1 |
| Total cases | 90 | 4 | 5 | 9 | 72 | 9 | 46 | 15 | 2 |

No appreciable difference was noted in results between obstructed and nonobstructed patients except for a slightly higher percentage of poor cases among the obstructed patients. (See Table XIIA.)

TABLE XII A

| | NONOBSTRUCTED | | OBSTRUCTED | |
|---|---|---|---|---|
| RESULT | NUMBER | PER CENT | NUMBER | PER CENT |
| Excellent | 62 | 21.9 | 10 | 12.1 |
| Good | 164 | 58.2 | 54 | 66.0 |
| Satisfactory | 47 | 16.8 | 13 | 15.8 |
| Poor | 9 | 3.1 | 5 | 6.1 |
| Total | 282 | 100 | 82 | 100 |

### POSTOPERATIVE HEMOGLOBIN VALUES

Table XIII indicates 347 postoperative hemoglobin determinations for patients according to sex. It also shows the result as to number of years follow-up study was carried out.

TABLE XIII. POSTOPERATIVE HEMOGLOBIN VALUES

| | 2 YEAR | | 3 YEAR | | 4 YEAR | | 5 YEAR | | 6 YEAR | | 7 YEAR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MALE | FEMALE | MALE | FEMALE | MALE | FEMALE | MALE | FEMALE | MALE | FEMALE | MALE | FEMALE |
| Anemia | 2 | 3 | 4 | 3 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 0 |
| Borderline | 4 | 3 | 4 | 5 | 1 | 1 | 3 | 3 | 0 | 3 | 0 | 1 |
| Normal | 76 | 14 | 41 | 11 | 38 | 6 | 49 | 6 | 19 | 1 | 34 | 5 |
| Total | 82 | 20 | 49 | 19 | 40 | 8 | 54 | 11 | 20 | 4 | 34 | 6 |
| Total cases | 102 | | 68 | | 48 | | 65 | | 24 | | 40 | |

Normal, hemoglobin greater than 12.5 Gm.; values as high as 17 Gm.
Borderline, hemoglobin greater than 11 Gm. but less than 12.5 Gm.
Anemia, hemoglobin values less than 11 Gm.

It was found that two years following surgery, the males showed a normal hemoglobin in 92.6 per cent of the cases as compared to 70 per cent in the females. At three years, 83.4 per cent males had normal hemoglobins, whereas the females totaled 57.8 per cent. Normal hemoglobins were found in the males in 95 per cent of the cases as contrasted with 75 per cent in the females at four years. At five years, the males had normal hemoglobins in 90.7 per cent of the cases as compared to 54.5 per cent in the females. Ninety-five per cent of the males and only 25 per cent of the females had normal hemoglobins at six years. Seven years following surgery hemoglobins were found to be normal in 100 per cent of the males, and 83 per cent of the females.

There was a marked difference in hemoglobin values between males and females as shown through the entire seven-year follow-up. Males appeared more capable of maintaining normal hemoglobins.

In the patients who were not bleeding from a recurrent ulcer, only one case was encountered of severe anemia which did not respond to iron therapy. This was the case of a woman who had a hemoglobin value of 6½ Gm. The cause of anemia could not be determined because of the patient's refusal to have further studies done.*

### POSTOPERATIVE WEIGHT CHANGES

There was a significant number of patients who had difficulty maintaining what would be considered normal weight. Although the inability to gain weight in patients who have had subtotal gastric resections is not uncommon, symptoms arising from this are rare.

Table XIII A indicates the weight changes that occurred in Series I and II:

TABLE XIII A. POSTOPERATIVE WEIGHT CHANGES

| SERIES | NUMBER WHO GAINED WT. | AV. WT. GAINED (POUNDS) | NUMBER WHO LOST WT. | AV. WT. LOST (POUNDS) | NO CHANGE |
|---|---|---|---|---|---|
| I | 154 | 14 | 108 | 11.9 | 23 |
| II | 47 | 14.6 | 17 | 9.2 | 3 |
| Total | 201 (57%) | 13.5 | 125 (35.5%) | 11.0 | 26 (7.3%) |

*Since this study was completed we have had the occasion of noting the occurrence of clinical pernicious anemia in one of our patients (K. E., No. 786716), operated upon in 1942 for a gastrojejunal ulcer. He previously had a gastrojejunostomy done in 1907, followed by a small gastric resection elsewhere in 1911.

### POSTOPERATIVE DIGESTIVE DIFFICULTIES

Table XIV shows the number of patients that had any digestive difficulty as reported by years for Series I and II, respectively.

"Multiple complaints" refers to those patients who had more than one digestive complaint. "None" refers to the patients who had no complaints, except for single minor complaints as listed.

There were 364 patients followed in Series I and II. Of these, 311, or 86 per cent, of the patients had no digestive difficulty whatsoever. Minor symptoms were found in 37, or 10 per cent, of the cases. Sixteen patients, or 4 per cent of the cases, had multiple complaints.

Follow-up was done on 292 patients in Series I. Of these 85.6 per cent were asymptomatic. Minor complaints were found in 10.3 per cent of the cases; and 4.1 per cent of the patients had multiple complaints.

Seventy-two patients were followed in Series II; 84.7 per cent were without digestive difficulties; 9.7 per cent had minor complaints; and 5.5 per cent had multiple complaints.

### "DUMPING SYNDROME"

The success or failure of operative procedures for ulcer in the past has been evaluated mainly on the basis of recurrent ulceration. This is the most important consideration. However, in recent years, a considerable awareness has occurred that there are patients who may suffer from symptoms which may to a greater or lesser degree deprive the patient of a good end result even in the absence of recurrent ulceration.

Realization that some disturbing symptoms followed anatomic alterations in the normal stomach and small bowel relations was noted by Hertz[44] in 1913. He observed the symptoms of sensation of fullness in a patient with a gastrojejunostomy. The symptoms were severe enough to force the patient to decrease the intake. He also noted in this patient, on fluoroscopic examination, that the stomach emptied rapidly and that there was an associated distention of the jejunum. Hertz believed that the distress was occasioned by this rapid emptying and sudden distention. He stated that the patient obtained relief by lying down and believed that the reason for this was the fact that with the patient prone, the stomal opening was no longer the most dependent portion of the stomach.

Mix[45] stated that in patients in whom distress arose of the nature just described following gastrojejunostomy, the symptoms were relieved by taking down the gastrojejunostomy and restoring normal gastrointestinal continuity.

With the increase in the number of subtotal gastric resections being done for peptic ulcer, these postprandial symptoms have been the subject of much discussion.

Eusterman and Balfour[46] stated that the symptoms were due to "too rapid emptying."

Snell[47] mentioned the syndrome, but believed it disappeared after the jejunum became accustomed to the new anatomic arrangement. Glaessner[48] stated that the symptoms were on the basis of hyperglycemia in some of the patients within the first half hour following the meal.

TABLE XIV. POSTOPERATIVE DIGESTIVE DIFFICULTY

| YEAR | TOTAL CASES | DEAD | NO RECORD | FOLLOWED | MULTIPLE DIGESTIVE COMPLAINTS | NONE | | NAUSEA VOMITING | BLOATING | HEARTBURN | DIARRHEA | PAIN | DUMPING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | | | | | |
| 1940 | 48 | 3 | 4 | 41 | 4 | 37 | | | | | 1 | | |
| 1941 | 51 | 8 | 3 | 40 | | 40 | | | 1 | 1 | | | |
| 1942 | 61 | 2 | 1 | 58 | 3 | 55 | EXCEPT | | 5 | | | | 2 |
| 1943 | 53 | 2 | 2 | 49 | 1 | 48 | | 1 | 1 | | 1 | | 4 |
| 1944 | 60 | 6 | | 54 | 1 | 53 | | 1 | 1 | | | | 2 |
| 1945 | 53 | 2 | 1 | 50 | 3 | 47 | | 4 | | 1 | 1 | 2 | 1 |
| Total* | 326 | 23 | 11 | 292 | 12 | 280 | | 6 | 8 | 2 | 3 | 2 | 9 |
| *Series II, Gastric and Pyloric Ulcers* | | | | | | | | | | | | | |
| 1940 | 15 | 4 | 1 | 10 | 1 | 9 | | | 1 | | | | |
| 1941 | 14 | 2 | 2 | 10 | | 10 | | | | | | | |
| 1942 | 15 | 2 | 1 | 12 | | 12 | EXCEPT | 1 | | | | | 2 |
| 1943 | 16 | 2 | | 14 | 2 | 12 | | | | | | | |
| 1944 | 21 | 3 | | 18 | | 18 | | | 2 | | 1 | | |
| 1945 | 9 | 1 | | 8 | 1 | 7 | | | | | | | |
| Total† | 90 | 14 | 4 | 72 | 4 | 68 | | 1 | 3 | | 1 | | 2 |

*Of these, 85.6 per cent (250 patients) had no digestive difficulties, 10.3 per cent (30 patients) had minor digestive difficulties, and 4.1 per cent (12 patients) had multiple digestive difficulties.

†Of these, 84.7 per cent (61 patients) had no digestion difficulties, 9.7 per cent (7 patients) had minor digestive difficulties, and 5.5 per cent (4 patients) had multiple digestive difficulties.

Lapp and Dibold[49] in 1933 called attention to the presence of hypoglycemia two and one-half hours following a meal. They found that in performing glucose tolerance tests on gastrectomized patients, there was an abnormally high rise above normal in blood sugar values within the first hour followed by a hypoglycemia two to two and one-half hours later.

Schwartz, Rheingold, and Necheles[50] were unable to correlate the level of blood sugar with the appearance of symptoms, and they believed symptoms to be based on distention of the upper part of the small bowel. Custer, Butt, and Waugh[51] also favored this as being the important factor.

A definite pattern of symptoms has been noted in the gastrectomized patient. These symptoms occur during the progress of eating, immediately after, or within one-half hour after finishing the meal. The patient becomes distended and has a sensation of fullness in the epigastric region. A feeling of an unpleasant sensation of general warmth occurs, and with this the occurrence of cold sweat mainly on the forehead. Some of the patients complain of weakness or fatigue; others feel very sleepy. There is an associated cardiac palpitation, and the patient may appear very pale. To the previously described symptoms has been given the name, "dumping syndrome." The name has been derived from the fact that it was believed the rapid dumping of food into the jejunum and resulting distention was responsible for this effect.

The incidence of "dumping syndrome" has variously been reported as varying from 5.6 to 7 per cent. Jordan[52] reported that "dumping syndrome" and recurrent ulcer accounted for 25 per cent of the unsatisfactory results following partial gastrectomy.

Miller[37] noted an incidence of 7 per cent in his cases. Custer and associates[51] reported 28 in 500 cases, or 5.6 per cent. Mateer,[53] commenting on Jordan's paper, stated an incidence of 14 per cent.

Custer, Butt, and Waugh[51] felt that the size of the stoma was related to the symptoms and modified the operative procedure from a Polya in which the entire cut end of the stomach is used for the anastomosis. He changed this to a Hofmeister modification in which the lesser curvature side is inverted, reducing the size of the stoma. He subsequently noted that when "dumping syndrome" appeared it was less severe and disappeared within a short time. Table XV shows the cases of "dumping syndrome" in Series I and II. Eleven patients, or 2.6 per cent, complained of symptoms of "dumping syndrome." In no case were the symptoms of a severe degree, but rather could be classified as moderate or mild in nature. With the exception of one patient (I. S.) all the patients were able to maintain normal nutrition. These patients have had to make some adjustments in their dietary intake and usual routing. They found that decreasing the size of the meals, avoiding liquids with meals, and eating more frequently, diminished their symptoms. Others learned that resting immediately after eating would tide them over the period of discomfort.

### POSTOPERATIVE QUANTITATIVE FOOD INTAKE

Table XVI shows the number of patients followed for each year and their ability to observe normal eating habits with regard to quantity and regularity for Series I and II, respectively.

The term "three regular meals" implies that the patient eats regularly and his intake is the average amount of normal people. The designation "three regular meals plus" refers to the patient with eats at a regular time, whose

TABLE XV. CASES OF "DUMPING SYNDROME"

| HOSPITAL NO. NAME, AGE, SEX | DIAGNOSIS | OPERATION DATE | WEIGHT OF RESECTED SPECIMEN (GM.) | PREOP. WT. (POUNDS) | PRESENT WT. (POUNDS) | SYMPTOMS |
|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | |
| 717018 (E.A.) 64 (m) | Duodenal ulcer with obstruct. | IVA 2/2/42 | 215 | 125 | 140 | Feels weak and exhausted for about 1 hr. after meals, mainly after heavy meals |
| 717995 (L.A.) 57 (f) | Duodenal ulcer with obstruct. | III 4/1/42 | 285 | 106 | 103 | Feels exhausted after meals, rests for ½ hr.; has slight epigastric distress |
| 726872 (L.R.) 36 (m) | Duodenal ulcer | III 1/19/43 | 165 | 190 | 193 | Perspires a great deal after meals for ½ hr. |
| 736926 (R.S.) 49 (m) | Duodenal ulcer | III 10/25/43 | 120 | 145 | 139 | Weakness and sweating after some meals relieved by lying down |
| 602509 (E.F.) 43 (f) | Duodenal ulcer | III 9/13/43 | 120 | 125 | 118 | Weakness, sweating, nausea for ½ hr. after meals relieved by lying down; does not occur after every meal |
| 749789 (I.S.) 61 (m) | Duodenal ulcer with hemorrhage & obstruct. | III 11/28/44 | 210 | 130 | 115 | Following meals has sensation of fullness, feels weak and drowsy and must lie down for 15 min. |
| 736835 (G.L.) 23 (m) | Gastrojejunal stomal ulcer, D.U. | III 11/15/43 | 285 | 139 | 147 | Sick feeling after meals, weakness, palpitation, and breaks out in cold sweat—lasts ½ to 1 hr. after meals |
| 741443 (T.C.) 52 (m) | Duodenal & gastric ulcer | III 3/20/44 | 172 | 130 | 133 | Becomes sleepy after evening meal, feels somewhat faint and dyspneic, better after lying down for ½ hr. |
| 753037 (A.S.) 56 (m) | Gastrojejunal | III 4/11/45 | | 135 | 144 | Has nausea, weakness, flushing of face, palpitation, feels faint, perspires freely for 15 min. to ½ hr. after meals |
| *Series II* | | | | | | |
| 691427 (C.M.) 59 (m) | Gastric ulcer | III 4/13/42 | 425 | 182 | 170 | Weakness and sweating after meals relieved by lying down, duration ½ to 1 hr. |
| 721674 (W.H.) 46 (m) | Gastric ulcer | III 7/17/42 | 200 | 140 | 160 | Feels weak and tired after some meals, becoming less severe and less frequent. |

TABLE XVI. POSTOPERATIVE QUANTITATIVE FOOD INTAKE

| YEAR | MALES AND FEMALES COMBINED: TOTAL CASES | DEAD | NO RECORD | QUANTITATIVE FOOD INTAKE: FOLLOWED | 3 REG. MEALS | 3 REG. MEALS+ | FSF |
|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | |
| 1940 | 48 | 3 | 4 | 41 | 25 | 10 | 6 |
| 1941 | 51 | 8 | 3 | 40 | 29 | 11 | |
| 1942 | 61 | 2 | 1 | 58 | 42 | 11 | 5 |
| 1943 | 53 | 2 | 2 | 49 | 31 | 15 | 3 |
| 1944 | 60 | 6 | | 54 | 37 | 14 | 3 |
| 1945 | 53 | 2 | 1 | 50 | 35 | 12 | 3 |
| Total* | 326 | 23 | 11 | 292 | 199 | 73 | 20 |
| *Series II, Gastric and Pyloric Ulcer* | | | | | | | |
| 1940 | 15 | 4 | 1 | 10 | 5 | 4 | 1 |
| 1941 | 14 | 2 | 2 | 10 | 7 | 3 | |
| 1942 | 15 | 2 | 1 | 12 | 10 | 2 | |
| 1943 | 16 | 2 | | 14 | 7 | 3 | 4 |
| 1944 | 21 | 3 | | 18 | 11 | 7 | |
| 1945 | 9 | 1 | | 8 | 5 | 3 | |
| Total† | 90 | 14 | 4 | 72 | 45 | 22 | 5 |

*Three regular meals, 199 or 68.1 per cent; 3 regular meals plus, 73 or 25.0 per cent; frequent small feedings, 20 or 6.8 per cent.

†Three regular meals, 45 or 62.5 per cent; 3 regular meals, 22 or 30.5 per cent; frequent small feedings, 5 or 6.9 per cent.

intake is slightly smaller than normal amounts, and includes supplemental feedings between meals. "Frequent small feedings" indicates that the patient is unable to take a normal size meal and therefore must eat frequently and smaller amounts.

There was a total of 364 patients followed in Series I and II with regard to quantitative food intake. Of these, 244 patients, or 67 per cent of the cases, were enjoying three regular meals; 95 patients, or 26 per cent of the cases, ate three regular meals plus supplemental feedings; 25 patients, or 6.5 per cent were restricted as to the amount of food they could eat at one time and also were eating frequently.

There were 292 patients followed in Series I. Of these, 68.1 per cent ate three regular meals; 25.0 per cent ate three regular meals plus supplemental feedings; and 6.8 per cent resorted to frequent small feedings.

In Series II there were 72 cases followed. Of the total, 62.5 per cent of the patients were able to eat three regular meals; 30.5 per cent ate three regular meals plus supplemental feedings; and 6.9 per cent ate frequent small feedings.

### POSTOPERATIVE FOOD INTOLERANCE

Table XVII indicates the number of patients with food intolerances by years for each of the two series.

There were 364 patients followed. The majority of patients followed in the study, 60.8 per cent, were able to eat all foods without restrictions; 34.7 per cent of the patients were able to eat a regular diet, but had difficulty with single foods; 4.4 per cent observed dietary restrictions for multiple foods.

Of the 292 patients followed in Series I, 61.9 per cent of the patients ate all foods without any restrictions; 31.5 per cent had no dietary restrictions except for single foods; 6.5 per cent observed dietary restrictions for multiple foods.

TABLE XVII. POSTOPERATIVE FOOD TOLERANCE

| YEAR | TOTAL CASES | DEAD | NO RECORD | FOLLOWED | RESTRICTED | ALL | | MILK | CHOC. | SWEETS | SPICY FOODS | FRIED FOODS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | | | | |
| 1940 | 48 | 3 | 4 | 41 | 5 | 36 | | 1 | | 6 | | |
| 1941 | 51 | 8 | 3 | 40 | 2 | 38 | | | 3 | 15 | 1 | |
| 1942 | 61 | 2 | 1 | 58 | 3 | 55 | EXCEPT | 7 | | 11 | | |
| 1943 | 53 | 2 | 2 | 49 | 4 | 45 | | 9 | | 7 | | |
| 1944 | 60 | 6 | | 54 | 3 | 51 | | 9 | 3 | 7 | | |
| 1945 | 53 | 2 | 1 | 50 | 2 | 48 | | 7 | | 6 | | |
| Total* | 326 | 23 | 11 | 292 | 19 | 273 | | 33 | 6 | 52 | 1 | |
| *Series II, Gastric and Pyloric Ulcers* | | | | | | | | | | | | |
| 1940 | 15 | 4 | 1 | 10 | 1 | 9 | | 1 | | 2 | 1 | |
| 1941 | 14 | 2 | 2 | 10 | 0 | 10 | | | | 2 | | |
| 1942 | 15 | 2 | 1 | 12 | 0 | 12 | EXCEPT | | | 3 | | |
| 1943 | 16 | 2 | 0 | 14 | 1 | 13 | | 2 | | | | 1 |
| 1944 | 21 | 3 | 0 | 18 | 0 | 18 | | 1 | | 2 | | 2 |
| 1945 | 9 | 1 | 0 | 8 | 0 | 8 | | | | | | |
| Total† | 90 | 14 | 4 | 72 | 2 | 70 | | 4 | | 9 | 1 | 3 |

*Of these, 61.9 per cent (181 patients) ate all foods without any restriction; 31.5 per cent (92 patients) had no dietary restrictions, except for single foods; 6.5 per cent (19 patients) observed dietary restrictions for multiple foods.

†Of these, 73.6 per cent (53 patients) ate all foods without any restriction; 23.6 per cent (17 patients) had no dietary restrictions except for single foods; 2.7 per cent (2 patients) observed dietary restrictions for multiple foods.

In Series II, of the 72 patients followed, 73.6 per cent of the patients ate all foods without any restriction; 23.6 per cent had no dietary restriction, except for single foods; and 2.7 per cent observed dietary restrictions for multiple foods.

It was found that a considerable number of patients were not drinking milk since the operation. The question arose as to whether this was due to an intolerance to milk or merely a dislike because of long usage in medical regimen prior to surgery. Symptoms of intolerance to milk were nausea, feeling of fullness, upper abdominal distress, and vomiting in some cases.

Table XVIII shows patients' tolerance to milk in Series I and II.

Of the 364 patients followed in the two series, 94 patients reported they did not drink milk postoperatively. Twenty-seven patients stated they did not drink milk preoperatively and postoperatively. A delnite aversion to milk was noted in 57 patients, or 16.9 per cent. These individuals reported no distress from milk, but had acquired a distaste for it from long usage as part of the medical regimen. The remaining 37, or 11 per cent, did not drink milk postoperatively because they were intolerant to it.

Eleven patients were studied who stated they were intolerant to milk. A Rehfuss duodenal tube was passed into the stomach and positioned under fluoroscope, so that the end of the tube lay just within the gastric pouch. Then 200 c.c. of 3½ per cent butterfat milk was placed in an ordinary intravenous flask which was completely covered to prevent the patient from knowing what was being administered. This was run in rapidly to simulate the patient's drinking milk under ordinary circumstances.

TABLE XVIII. TOLERANCE TO MILK

| YEAR | TOTAL CASES | DEAD | NO RECORD | FOLLOWED | USE OF MILK PREOP. YES | USE OF MILK PREOP. NO | USE OF MILK POSTOP. YES | USE OF MILK POSTOP. NO | DEFINITELY INTOLERANT |
|---|---|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | |
| 1940 | 48 | 3 | 4 | 41 | 37 | 4 | 28 | 13 | 1 |
| 1941 | 51 | 8 | 3 | 40 | 37 | 3 | 29 | 11 | |
| 1942 | 61 | 2 | 1 | 58 | 51 | 7 | 37 | 21 | 7 |
| 1943 | 53 | 2 | 2 | 49 | 44 | 5 | 33 | 16 | 9 |
| 1944 | 60 | 6 | | 54 | 54 | | 28 | 26 | 9 |
| 1945 | 53 | 2 | 1 | 50 | 46 | 4 | 35 | 15 | 7 |
| Total | 326 | 23 | 11 | 292 | 269 | 23 | 190 | 102 | 33 |
| *Series II, Gastric and Pyloric Ulcers* | | | | | | | | | |
| 1940 | 15 | 4 | 1 | 10 | 9 | 1 | 9 | 1 | 1 |
| 1941 | 14 | 2 | 2 | 10 | 9 | 1 | 7 | 3 | |
| 1942 | 15 | 2 | 1 | 12 | 12 | | 9 | 3 | |
| 1943 | 16 | 2 | | 14 | 13 | 1 | 8 | 6 | 2 |
| 1944 | 21 | 3 | | 18 | 17 | 1 | 15 | 3 | 1 |
| 1945 | 9 | 1 | | 8 | 8 | | 5 | 3 | |
| Total | 90 | 14 | 4 | 72 | 68 | 4 | 53 | 19 | 4 |

Table XIX shows patients' reaction to milk and cream, and emptying time of the stomach after administering milk and cream.

One patient noted slight transitory upper abdominal distress. Another complained of nausea, weakness, and had marked diaphoresis. The difficulty

lasted for about fifteen minutes and gradually disappeared. This is the only case observed here where symptoms elicited were comparable to those of "dumping syndrome."

In nine patients no distress was noted during the period of administration and for one-half hour following. It would appear that the psychologic factor might play a part in patients who were intolerant to milk.

Four patients were given 50 c.c. of 35 per cent butterfat cream in the same manner as that described for milk, and no distress was noted in any case.

In five patients there was moderate increase in emptying time of the stomach after the administration of milk.

In the three of the four patients who were given cream, there was an appreciable delay in the emptying time of the stomach.

TABLE XIX. TOLERANCE TO MILK AND CREAM

| HOSPITAL NO., NAME SEX | DIAGNOSIS | WEIGHT OF RESECTED SPECIMEN | REACTION TO MILK | CONTROL* EMPTYING TIME (MIN.) | AFTER* MILK (MIN.) | REACTION TO CREAM | EMPTYING TIME* AFTER CREAM (MIN.) |
|---|---|---|---|---|---|---|---|
| 749446 (T.B.) (f) | Duodenal ulcer | 195 Gm. | None | 12 | 25 | | |
| 641839 (F.P.) (m) | Duodenal ulcer | 145 Gm. | None | 15 | 18 | None | 41 |
| 752872 (G.M.) (m) | Duodenal ulcer | 175 Gm. | Sl. transitory upper abd. distress | 10 | 18 | | |
| 697905 (J.T.) (m) | Duodenal ulcer and gastric | 305 Gm. | None | 12 | 16 | None | 20 |
| 685488 (E.H.) (m) | Duodenal ulcer | 301 sq. cm. | None | 10 | 15 | | |
| 691274 (H.P.) (m) | Gastric | 290 sq. cm. | None | 14 | 14 | None | 30 |
| 693845 (B.H.) (f) | Duodenal ulcer | 150 Gm. | None | 10 | 15 | | |
| 758321 (E.O.N.) (m) | Duodenal ulcer | 185 Gm. | None | 10 | 14 | | |
| 709645 (J.S.) (m) | Duodenal ulcer | 220 Gm. | None | 11 | 23 | | |
| 753204 (J.W.) (f) | Duodenal ulcer | 235 Gm. | None | 10 | 10 | | |
| 753037 (A.S.) (m) | Gastro-jejunal | No wt. | Began to perspire, complained of feeling weak, tachycardia, and nausea | 3 | 25 | None | 54 |

*Thin barium mixture of 150 c.c. water and 70 Gm. of barium.

Carbohydrate, particularly in form of desserts, was most common food listed with which patients had difficulty. Sweets were not tolerated in 61, or 16.7 per cent, of the patients. Symptoms listed were distress, nausea, and vomiting in some cases.

Eleven patients were investigated for intolerance to sweets by putting 50 Gm. of glucose in 200 c.c. of water into the stomach. This was administered in the same manner as was done with milk. Blood sugars were taken for fasting values; at 15 minute intervals for the first hour; then at one-half hour intervals for the remainder of the two and one-half hour period. Only one patient complained of any distress. He had slight nausea during the first fifteen minutes of the test.

The blood sugar values in the 11 patients showed a rapid and often an abnormally high increase. They also showed abnormally low values at two to two and one-half hours. The time of maximal increase of blood sugar was found to be at thirty minutes in 7 of the cases, forty-five minutes in 3 cases; and one hour in 1 case.

TABLE XX. GLUCOSE TOLERANCE TEST

| HOSPITAL NO., NAME, SEX | DIAGNOSIS | REACTION TO GLUCOSE | FASTING | 15 MIN. | 30 MIN. | 45 MIN. | 1 HR | 1½ HR. | 2 HR. | 2½ HR. |
|---|---|---|---|---|---|---|---|---|---|---|
| 709292 (R.I.) (m) | Duodenal ulcer | None | 80 | 179 | 188 | 151 | 143 | 124 | 75 | 56 |
| 725986 (R.K.) (f) | Duodenal ulcer | None | 133 | | 364 | | 263 | 174 | | 148 |
| 761214 (R.P.) (m) | Duodenal ulcer | Slight nausea 15 min. | 65 | 151 | 192 | 120 | 90 | 39 | | 66 |
| 641839 (E.P.) (m) | Duodenal ulcer | None | 95 | 171 | 180 | 133 | 130 | 89 | 71 | |
| 638690 (E.R.) (f) | Duodenal ulcer | None | 71 | 208 | 273 | 289 | 200 | 130 | 87 | |
| 714541 (J.B.) (m) | Duodenal ulcer | None | 61 | 105 | 115 | 119 | 122 | 40 | 44 | |
| 708689 (J.R.) (m) | Duodenal ulcer | None | 80 | 149 | 158 | 152 | 84 | 44 | | |
| 700113 (S.S.) (f) | Gastric | None | 110 | 235 | 303 | 227 | 118 | | 104 | 102 |
| 758321 (E.N.) (m) | Duodenal ulcer | None | 116 | 220 | 258 | | 289 | 136 | 167 | |
| 758311 (E.D.) (m) | Duodenal ulcer | None | 85 | 167 | 214 | 238 | 187 | 105 | 77 | 66 |
| 643563 (J.K.) (m) | Duodenal ulcer | None | 105 | | 283 | 149 | 83 | 79 | 77 | |

Two cases showed an increase over 210 mg. per cent during the first fifteen minutes. In six of the cases the blood sugar was markedly increased.

In the hypoglycemic period there were four patients whose blood sugars were 66 mg. per cent or lower. One had a blood sugar value of 39 mg. per cent at the one and one-half hour period without experiencing any symptoms. No patients with low blood sugar values had symptoms.

From this small series of patients, it appears that there is no relation between blood sugar values and the occurrence of symptoms. No distress occurred in these patients from the ingestion of a hypertonic glucose solution, although they claimed distress by carbohydrates.

Table XX shows the blood sugar values obtained.

### POSTOPERATIVE ABILITY TO WORK

It has been stated that the patient should be capable of carrying on regular employment to warrant classification of a good result. In the study, 341 cases were followed as to the patient's ability to work. Table XXI shows the postoperative ability to work according to sex, type of work, and year followed, for Series I and II, respectively.

The type of work was divided into heavy, medium, and light for both sexes. These designations were set up according to work usually done by men and women. Males classified as doing heavy work were farmers, machinists, common laborers, and men whose occupations required expenditure of considerable physical exertion. Females employed in heavy manual labor outside of home, particularly heavy farm chores, were placed in "heavy type" classification.

Men employed in a managing or supervisory capacity, clerks in stores, or those whose jobs demanded considerable physical movement were classed in "medium type" work. Women doing their own housework or working as light domestics were also classified "medium."

Men in executive desk positions, white collar workers, and those doing sedentary work were classified as "light." Women doing light household tasks, secretaries, and office personnel were classified as doing "light" work.

Of the 341 cases in which follow-up study was done, 283 were males and 58 females.

Table XXI A indicates the total patients followed in the two series according to their ability to work, and the type of work they are doing.

TABLE XXI A

| | MALES (283) | | FEMALES (58) | |
|---|---|---|---|---|
| | NUMBER | PER CENT | NUMBER | PER CENT |
| Heavy type work | 155 | 54.8 | 6 | 10.3 |
| Medium type work | 60 | 21.2 | 35 | 60.3 |
| Light type work | 44 | 15.5 | 16 | 27.7 |
| Not working | 20 | 7.1 | — | — |
| Unable to work | 4 | 1.4 | 1 | 1.7 |
| Total | 283 | 100.0 | 58 | 100.0 |

Of the 24 males not working, only 4 were unable to work because of difficulties relating to their postoperative conditions. The remaining 20 patients were not working because of a condition not related to their operation, such as pulmonary tuberculosis, postmeningitis, asthma, arthritis, syphilis, lateral sclerosis, psychoses, blindness, senility, or retirement.

TABLE XXI. POSTOPERATIVE ABILITY TO WORK ACCORDING TO SEX

| YEAR | TOTAL CASES | DEAD | NO RECORD | FOLLOWED | LIGHT | MEDIUM | HEAVY | NONE NUMBER | NONE REASON |
|---|---|---|---|---|---|---|---|---|---|
| *Series I, Duodenal Ulcer, Gastrojejunal Ulcer* | | | | | | | | | |
| Males: | | | | | | | | | |
| 1940 | 42 | 2 | 5 | 35 | 5 | 3 | 23 | 4 | 1 Blind<br>1 Retired<br>2 Unable to work |
| 1941 | 37 | 7 | 6 | 26 | 5 | 1 | 16 | 4 | 3 Pulmonary Tbc.<br>1 Bronchitis and asthma |
| 1942 | 54 | 2 | 7 | 43 | 8 | 7 | 25 | 3 | 1 Postmeningitis<br>1 Unable to work<br>1 Old age |
| 1943 | 46 | 2 | 6 | 38 | 2 | 10 | 25 | 1 | 1 Arthritis |
| 1944 | 49 | 1 | 2 | 46 | 11 | 13 | 19 | 3 | 2 Retired<br>1 Blind |
| 1945 | 43 | 2 | 2 | 39 | 8 | 10 | 15 | 6 | 2 Retired<br>1 Psychosis<br>1 CNS syphilis<br>1 Unable to work<br>1 Lateral sclerosis |
| Total | 271 | 16 | 28 | 227 | 39 | 44 | 123 | 21 | |
| Females: | | | | | | | | | |
| 1940 | 6 | 1 | | 5 | 1 | 3 | | 1 | 1 Unable to work |
| 1941 | 12 | 1 | 1 | 10 | | 8 | 2 | | |
| 1942 | 9 | | | 9 | 4 | 4 | 1 | | |
| 1943 | 7 | | 1 | 6 | 2 | 4 | | | |
| 1944 | 11 | 5 | | 6 | 3 | 2 | 1 | | |
| 1945 | 10 | | | 10 | 5 | 5 | | | |
| Total | 55 | 7 | 2 | 46 | 15 | 26 | 4 | 1 | |
| Grand total | 326 | 23 | 30 | 273 | 54 | 70 | 127 | 22 | |
| *Series II, Gastric and Pyloric Ulcer* | | | | | | | | | |
| Males: | | | | | | | | | |
| 1940 | 9 | | 1 | 8 | 2 | 1 | 4 | 1 | Senility |
| 1941 | 14 | 2 | 2 | 10 | | 3 | 7 | | |
| 1942 | 11 | 1 | 2 | 8 | | 3 | 4 | 1 | Neuritis |
| 1943 | 12 | 2 | 1 | 9 | | 2 | 6 | 1 | Arthritis<br>mental depress. |
| 1944 | 19 | 3 | 1 | 15 | 1 | 4 | 10 | | |
| 1945 | 7 | 1 | | 6 | 2 | 3 | 1 | | |
| Total | 72 | 9 | 7 | 56 | 5 | 16 | 32 | 3 | |
| Females: | | | | | | | | | |
| 1940 | 6 | 4 | | 2 | | 2 | | | |
| 1941 | 0 | | | | | | | | |
| 1942 | 4 | 1 | 1 | 2 | 1 | 1 | | | |
| 1943 | 4 | | | 4 | | 4 | | | |
| 1944 | 2 | | | 2 | | 2 | | | |
| 1945 | 2 | | | 2 | | | 2 | | |
| Total | 18 | 5 | 1 | 12 | 1 | 9 | 2 | 0 | |
| Grand total | 90 | 14 | 8 | 68 | 6 | 25 | 34 | 3 | |

The one female reported in Table XXI A unable to work had a recurrent ulcer following a Group IV operation.

It was found that the majority of patients who were doing light work returned to their employment in six to seven weeks. Those doing medium type work returned in approximately two to two and one-half months. With the exception of a few cases, the majority of patients returned to heavy type work in three months.

## SUMMARY

1. We have followed what we believe are the criteria for a satisfactory operation for peptic ulcer.

First, effective reduction of gastric secretion must be accomplished. This requires at least a 75 per cent resection of the stomach with excision of the entire lesser curvature and antrum.

Second, the anastomosis with the jejunum must be made in such a manner that the proximal duodenal-jejunal loop is as short as possible. This is possible only if a retrocolic anastomosis is performed.

Finally, removal of the ulcer-bearing area in the duodenum is not important so long as the antral mucosa is excised.

2. In this investigation 416 patients consecutively operated upon for peptic ulcer were considered. The study included all the patients treated from January 1, 1940, to July 1, 1945. Patients were followed by questionnaire and clinical examination in the outpatient department. Investigation covered the state of health of the patient postoperatively. The patients investigated and evaluated were followed for at least two years, and some seven years. They were classified postoperatively into four categories: namely, "excellent," "good," "satisfactory," and "poor."

3. The cases were divided into two series. Series I consisted of 326 cases in which the problem was that of duodenal ulcer. In Series II there were 90 cases with ulcerations on the gastric side of the pylorus.

4. In the complete series there were 343 males and 73 females, indicating a ratio of 4.6 to 1.

5. The average age of patients of Series I was found to be 45.8 years. In Series II, the average age was 54.3 years.

6. The average duration of symptoms shown in each of the series was 12.9 years in Series I and 8.4 years in Series II.

7. Pain occurred as a symptom in 96 per cent of the cases. In 20 per cent of the patients, pain occurred as the only symptom. Hemorrhage appeared as a symptom in 51.6 per cent, and obstruction was present in 22.3 per cent.

8. The over-all mortality of the patients operated upon was 4.5 per cent. This included the seven cases of emergency operations for acute hemorrhage. Mortality for elective surgery was 3 per cent.

9. The average weight of the resected specimen in Series I in the nonobstructed patients was 182.23 Gm.; and the average weight in the obstructed patients was 246.14 Gm. In Series II, the average weight of the specimen in the nonobstructed patients was 207.3 Gm. and in the obstructed 285.4 Gm.

The average weights of the resected specimens in the female patients who were not obstructed was significantly smaller than in the males in the cases of duodenal and gastric ulcer. In the obstructed patients, this relationship was not uniformly seen in all the series.

10. Achlorhydria was found following the Group III operation in Series I as follows: 85.6 per cent of cases were achlorhydric; 85 per cent males, and 90 per cent females. In Series II, achlorhydria was found in 88 per cent of the cases; 88 per cent males, and 89 per cent females.

Achlorhydria was found in Group IVA operation in Series I as follows: 84.8 per cent of cases were achlorhydric; 82.7 per cent males, and 100 per cent females.

In Group IV operation, achlorhydria was found in 71 per cent of the cases. It was shown that achlorhydria was more easily obtained in females than in males.

11. Groups III and IVA were the standard operative procedures used in the surgical treatment of the cases. The Group IV operation was discontinued early in 1941, since it was quickly realized this operation was unsatisfactory. Of the patients who had Group IV operation, 50 per cent were unsatisfactory. There were only six patients followed with this type operation.

Patients who had Group III operation in Series I revealed a favorable result in 96.6 per cent of the cases. The unsatisfactory result in this Series was 3.4 per cent. The recurrence rate was found to be .86 per cent.

In patients who had Group IVA in Series I, a favorable result occurred in 98.2 per cent of the cases. The unsatisfactory result of 1.8 per cent included one recurrent ulceration. The recurrence rate in Series I with Group III and IVA operation was 1 per cent.

In Series II, a favorable result was obtained in 97.3 per cent of the patients. There were no recurrent ulcerations in this Series.

12. A favorable result was shown in 96 per cent of the males and 95.7 per cent of the females in Series I. In Series II, a favorable outcome was shown in 96.7 per cent of the males and 100 per cent of the females.

13. No appreciable difference was noted in results between obstructed and nonobstructed patients.

14. Of the 51 patients followed seven years, hemoglobin values were obtained in 40 cases. Normal hemoglobin was noted in 100 per cent of the males and 83 per cent of the females. Only one case of severe anemia, which did not respond to iron therapy, was encountered.

15. There was a total of 364 patients followed in Series I and II, with regard to postoperative digestive difficulties. There were no digestive difficulties whatever in 311, or 86 per cent. Minor symptoms were found in 37, or 10 per cent; and 16, or 4 per cent, had multiple complaints.

16. There were 2.6 per cent of the patients who complained of symptoms of the so-called "dumping syndrome." In no case were the symptoms of a severe degree.

17. There were 364 patients followed in Series I and II with regard to quantitative food intake. Of these, 244 patients, or 67 per cent, enjoyed three regular meals; 95 patients, or 26 per cent, ate three regular meals plus supplemental feedings; and 25 patients, or 6.5 per cent, ate frequent small feedings.

18. Of the 364 patients followed in Series I and II regarding food intolerance, it was found that 60.8 per cent were able to eat all foods without restriction; 34.7 per cent were able to eat regular diet, but had difficulty with a single food; and 4.4 per cent observed dietary restrictions for multiple foods.

19. Ninety-four patients reported they did not drink milk postoperatively; 16.9 per cent of the patients did not drink it because they had acquired a distaste for it from long usage as part of the medical regimen.

In 11 patients studied for intolerance to milk one patient had slight distress and another had symptoms quite typical of the "dumping syndrome" following the administration of milk.

In a small series of cases studied for intolerance to cream no distress was noted.

It would appear that some intolerance to milk and cream might be explained on a psychologic basis.

Intolerance to sweets was noted in 16.7 per cent of the cases. Eleven patients were studied for intolerance to sweets by administration of glucose into the stomach and the simultaneous determination of blood sugars. Blood sugar values obtained showed rapid initial rise within the first 30 minutes. Abnormally low values were obtained at two to two and one-half hours.

20. On investigation of the work record of the patients, it was found that 91.5 per cent of the males were engaged in regular employment at the present time; 7.1 per cent were not working because of a condition not related to the operation, or were retired; and 1.4 per cent were unable to work because of difficulties relating to the postoperative condition.

Of the females, 98.3 per cent were engaged in regular employment at the present time; and one patient, 1.7 per cent, was not working because of recurrent ulcer.

## CONCLUSION

It appears from this follow-up investigation and evaluation that the Group III and IVA operations indicated a gratifying number of favorable results. The majority of patients have been freed from the disease, are not threatened with constant danger of complications, and are restored to a more normal way of living. They are able to enjoy life without observing dietary restrictions, and to resume gainful and useful employment.

There were a small number of patients who, although benefited by the operation and enjoying fairly good health, reported minor difficulties. None of these difficulties interfered with the patient's way of living, and were not severe enough to warrant concern. All of the patients were found to have made a very good adjustment.

The operation as practiced here for peptic ulcer has resulted in only *three recurrences, a recurrence rate of less than 1 per cent. The mortality in elective operations was 3 per cent.*

Subtotal gastric resection has been shown at this time to be an eminently satisfactory method of affording a very favorable result. Until other means of treatment are developed which will produce a more satisfactory result, subtotal gastrectomy will continue to be the best approach to the problem of peptic ulcer.

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